POWER PLANT ENGINEERING

GENERATION, TRANSMISSION AND UTILIZATION OF STEAM, ELECTRIC, DIESEL AND HYDRAULIC POWER

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A. W. KRAMER, RICHARD H. MORRIS, Associate Editors.

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This night view taken from a high wall of the Columbia River Canyon gives one a vivid impression of the enormity of the undertaking in the building of Grand Coulee Dam

The Nerve of Him!

FOR UNTOLD AGES the mighty Columbia has proceeded, for the most part peacefully but often tempestuously, on its long way to the sea. At times it met with obstacles which diverted its course but never was it held in check. Millions of years ago a series of successive floods of molten lava poured through fissures in the earth's crust and spread out over what is now eastern and central Washington, gradually pushing the Columbia from its course and forcing it to detour far to the north and west. Here the river cut for itself a canyon as much as 1600 ft. deep in places and bounded on one side by precipitous cliffs of lava and on the other by the granite hills of the Okanogan Highlands.

During the last great ice age, a thick sheet of ice moved southward into northern Washington, crossing and completely filling the deep gorge of the Columbia. Once again the path of the great river was blocked, but, undaunted, the river rose to the occasion and as a result of the ice obstruction the upstream portion of the gorge was converted into a vast lake whose rising waters ultimately spilled over through several low points in the south wall of the gorge, cutting a series of complex channels in the lava crust to the southwestward.

As the ice age passed and the ice receded, the gorge opened up once more and in time the Columbia resumed its ancient course, but the channels through which the water had overflowed remained—vast dry rivers and falls. Though long dried up, these prehistoric river beds remain; they are plainly visible today and are known as coulees, the largest, Grand Coulee.

But now, an even more astonishing thing has begun to happen. Once more the path of the river is being blocked but this time not by an ice sheet, not by geologic forces or volcanic upheavals but by puny man—man, the upstart. With all the supreme effrontery for which he is noted, this little hairless mammal arises to throw an obstacle in the way of the Columbia—the mighty Columbia which in its time has matched forces with those of ice ages and volcanic upheavals! Such audacity has never been recorded; the nerve of him!

And yet, in man, the Columbia for once is going to find its match. In time, yes, the river will get through, but it will get through only as man will let it. Once again the ancient bed of the Grand Coulee will fill with water but this time it will serve as a great irrigation reservoir.

The enormity of this project staggers the imagination. The twelve million cubic yards of concrete entering into its construction is well over three times that required for Boulder Dam and that project paled into insignificance anything of its nature ever done before. Whatever one's political sympathies or economic views regarding this project, from an engineering standpoint, it must be admitted, it stands supreme and it cannot but command profound admiration and respect for those responsible for its construction.

WITH THE EDITORS

Welding Art Applied in the Power Plant Industry

FROM THE EARLY years of this century the art of fusion welding has made steady progress in industry. The advancement has never run wild to heights it could not maintain but step by step the difficulties have been overcome until now industry accepts this type of joints for metal in almost every kind of structure and pressure vessel.

Fusion welding whether with gas or electricity is among the newer arts and as such has been handicapped by the necessity of developing artisans capable of welding jobs without flaws. There has been the necessity also of designing joints to suit the special needs of industry, testing them to destruction in the shop and giving them thorough trial in service before they have been fully accepted as good practice. No small part of the development of this art has been the metallurgical problems that have perplexed welding engineers in compounding electrodes suitable for particular purposes. The most difficult task of all has been getting the industries and the public generally to accept welded joints with the same confidence that they have accepted bolted or riveted joints. This, however, was not thoroughly accomplished until the practice of examining important welds by means of the X-ray was developed. This accomplished, welding is almost universally accepted.

In the power plant, fusion welding has countless applications from the repair of cracked castings and structural parts of equipment to the building up of worn parts of machinery, the fabrication of piping, the patching of boilers and other pressure vessels, and even the welding of the boiler seams themselves in the highest pressure units.

Like in other arts, many advantages of welding have not been realized until they have proved themselves out in practice. Boilers with welded seams, for instance, have proved themselves practically free from embrittlement troubles. Piping layouts in crowded quarters, frequently difficult to fabricate with standard fittings, are readily handled with welding methods. One of the newer uses is in the construction of smoke stacks, a detailed description of which appeared recently in the pages of this magazine.

Upon this art, an entire line of welding-end valves and fittings for all kinds of piping has been developed by all leading manufacturing concerns in the field and the need for welding equipment has resulted in the building up of a number of manufacturing companies as well as special departments of established factories.

In a paper presented at the recent meeting of the American Welding Society, A. S. Douglass and L. W. Clark, both associated with the Detroit Edison Co., make a significant statement relative to the use of power by the three main welding processes: arc, gas and resistance. "The heat for arc welding is provided by an electric arc struck from the welding electrode, a steel rod about ⅛ in. diameter and 14 in. long, to the parts to be welded together. Each pound of electrodes consumes 2½ kw-hr. and there were 6½ million pounds of electrodes welded in 1936. Although the welding heat in gas welding is supplied by burning gases, oxygen and acetylene, electric power to the extent of 7,000,000 kw-hr. was used last year in manufacturing these gases. The power used by the large number of resistance welding machines is estimated to be 40,000,000 kw-hr. Summing up the grand total of 63,000,000 kw-hr. of electric power was used by welding in 1936."

Thus we see that not only is the art of welding an extremely important aid in the building and maintenance of a power plant but its use in industries is a substantial load builder for the plant after it is put into operation.

Fuel Specifications

DIESEL ENGINES operate on a wide variety of fuels ranging from good to very bad. Engine capacity, efficiency, reliability and availability depend to a large extent on the grade of fuel used and the use of inferior grades is usually false economy. The engine manufacturers should be consulted on the suitable quality and it should be purchased on strict specifications to insure uniformity. Uniform specifications have been prepared but unfortunately do not allow the tolerances that are necessary to meet the real or imagined needs of all groups. Recommendations of manufacturers are limited by performance and maintenance of the engines while oil companies say meeting the proposed specifications would increase costs and the user must as always hold the bag. Perhaps the newly formed Diesel Engine Users Association will serve as an effective agency to keep the voice of the user from being drowned out by the cross talk between the manufacturer telling what engines can be built to burn and refiners telling what they can make.

The Old Reliable Goes Wrong

YEARS OF EXPERIENCE have taught the engineer that the boiler gage glass is a pretty consistent and reliable device but in spite of this the remote water level indicator and recorder has made headway of recent years because of the large size of modern boilers and the tendency to centralize instruments on a control panel.

Through all this the operator has been a bit skeptical of the remote device and always keeps a weather eye on the old reliable gage glass, "just in case—." The "just in case," however, may be on the other foot. Recently a remote recorder, with separate connections to the boiler drum, registered low but the gage glass showed the level right up to the mark. Consistent with good operating practice the glass was taken as correct—that is until the low water alarm sounded. A small leak on the steam connection raised the level in the glass and gave a false reading.

The moral is simple: Never take anything for granted, even a dead sure thing like a gage glass reading.

BY-PRODUCT POWER for the FOOD INDUSTRY

Post Products Div. of General Foods Corp. at Battle Creek, Mich., sets new industrial standard with 650 lb., 720 deg. F., by-product power, single unit power plant. Steam standby provided by old boilers, supplementary power from the utility system

FROM THE FERTILE BRAIN of C. W. Post sprang an idea which germinating in a modest Battle Creek barn, grew into the Post Products Division of General Foods Corp. Today that barn still stands, externally unchanged, a monument to the past, internally a monument to the future for it houses the laboratories, focal point of the process control and future development.

From a few packages of a new beverage in 1895 to a daily output of 75 cars of breakfast food and beverage today, tells the story quite completely to an engineer but it does not bring out the influence the growth of an industry had on the living habits of the public. Post Toasties, Grape-nuts, Grape-nuts Flakes, Post's 40% Bran Flakes, Whole Bran Shreds, Huskies and Postum, are now more than household words—they are necessities to a generation whose parents had to depend on some form of cooked cereal or cornmeal mush for breakfast.

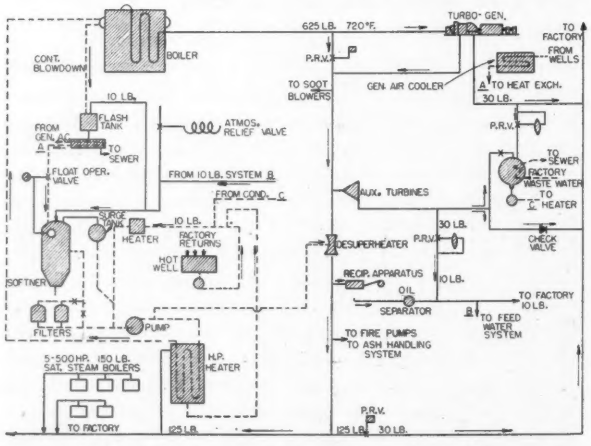


Fig. 1. Simplified flow diagram showing the four steam pressure systems used; 650 lb. for power generation; 125 lb. for process, auxiliary drive and feed heating; 30 lb. for process and heating; 10 lb. for heating and feedwater system

This change from uncooked to prepared cereals meant transferring the cooking problem from the kitchen to the factory. Here it is most conveniently done by steam. The boiler plant for processing came into the picture. Power for operating the machinery was also necessary, doubly important in this case, for the products of the company are untouched by human hands from the raw material to the table. This means more machinery and more power to drive it, packages and cartons to be made and filled and conveyed to the cars.

Up to recently, steam for processing and heating was supplied by five Sterling stoker fired boilers operated at 150 lb. pressure. Power was purchased from the public utility system. By 1934 the boiler plant was old and the operating cost high, the steamload had reached a peak of over 50,000,000 lb. per mo., and it seemed advisable to look into the possibility of by-product power generation with high pressure steam and modern equipment.

Preliminary Survey

The management placed this in the hands of E. J. Grimmett of the General Foods Corporation engineering staff. Mr. Grimmett made a thorough survey and gave detailed consideration to a number of possibilities ranging from a simple boiler plant to complete generation of all electric power. He recommended: a single 650 lb., 720-deg. F. boiler fired by two unit pulverizers; one 2500-kw. back pressure extraction turbine unit; purchase of power beyond by-product generation; more complete coordination of steam and electric loads; and certain factory piping and equipment changes to reduce the 125-lb. steam system demand and increase that of the 30 lb. system.

These studies and plans were turned over to Stone & Webster Engineering Corp. for verification and a separate survey checked the original estimates and

Fig. 2. Looking from the electrical bay over the 2500 kw. turbine to the new boiler. Two unit mills are in the basement under the coal hoppers

designs so closely that this organization was given a contract to proceed with the detailed design and build the plant. This was done under the supervision of Mr. Grimmett and completed last year at a total cost of slightly over $400,000 for the power plant, necessary outside piping and minor equipment changes called for by the complete program.

Basis of Design

Fundamentally, the new plant was predicated on: Utilization of a cheaper lower grade fuel than could be burned on the old stokers; higher efficiency of modern boilers; by-product generation of power but with provision for expansion to complete power generation later at minimum cost; and the most effective use of process steam. That the proposal was sound is shown by the actual performance which, under J. W. Odlum, chief power plant operating engineer, bettered the original estimates of savings by about 10 per cent due to a fortunate circumstance of slightly heavier loads than anticipated and conservative preliminary estimates. For the first 8 mo. of this year the new plant showed a saving of approximately $68,000 net after allowing for all fixed charges, depreciation, taxes and insurance. On the same basis the total operating cost for the same period was about $220,000. Peak production, and consequently power and steam loads, occur during the summer months and August production approximated 56,000,000 lb. of steam and 2,200,000 kw-hr., about two thirds of the latter being generated and a third purchased.

Old boilers were not disturbed but were left for standby. In fact they are used for peak loads rather than force the new boiler over 100,000 lb. per hr. for extended periods. There has been no difficulty in operating these older natural draft units in parallel with the new forced and induced draft boilers which discharge to the same stack. As no power standby is provided, forced outage of the new turbine would mean throwing the entire electric load on the utility system and the new demand, established for the ensuing 12 mo. period, would mean an extra annual charge of about $15,000. Outage of the high pressure boiler would not be so serious as about 1000 kw. can be carried on the new turbine by using 125 lb. steam through the extraction opening. Although these points were given due consideration, they are considered remote.

Reference to the flow diagram, Fig. 1, will show the fundamental simplicity and flexibility of the layout. Four steam pressures are used: 650 lb., 720 deg. F. for power generation; 125 lb. for auxiliary drives, process and high level feedwater heating; 30 lb. for heating and process; and 10 lb. for heating and the feedwater system. The 125 lb. system is supplied from extraction up to a maximum flow of 90,000 lb. per hr.; the 30 lb. system is supplied from the main turbine exhaust; and the 10 lb. system from the auxiliary exhaust and flash from the continuous blowdown system. In the event of unusual steam consumption on any system, pressure is maintained through reducing valve stations from the next higher pressure system.

Condenser Adds Flexibility

Additional flexibility is provided by a small Griscomb-Russell condenser with a maximum condensing capacity of 35,000 lb. of steam per hr. based on a temperature rise of cooling water from 80 to 180 deg. F. In case of an undue disturbance in the low pressure system this is cut into the 30 lb. system automatically by a pressure operated valve. Condensate is normally pumped direct to a Cochrane deaerating heater but may be drained to a condensate receiver tank below the basement floor level. The condenser is operated only in the summer when there is no heating load. Battle Creek is fortunate in having large quantities of cool water close to the surface and the 100 lb. factory supply system is supplied from wells by six centrifugal pumps with a combined capacity of 3600 g.p.m. All power plant cooling and condensing water is taken from the

waste process supply and stored in a large tank on the third floor.

Auxiliaries are all supplied from the 125 lb. system but in two groups. Three new Terry turbines, on the fans and boiler feed pumps, are supplied by superheated steam (normally extracted from the turbine but sometimes mixed with steam from the Smoot 650 to 125-lb. reducing valve) taken from a point preceding the desuperheater, while the old reciprocating units, air compressors, vacuum pumps and fire pump are supplied from a point following the desuperheater. The new power plant auxiliary turbines, one fan and two boiler feed pump drives, exhaust to the 30-lb. system, or, to the 10-lb. system through an automatic pressure regulating valve. Old reciprocating units exhaust to the 10-lb. system through a Cochrane oil separator to avoid contamination of the feedwater.

A portion of the old building was removed and a new section approximately 35 ft. wide was added, giving a new building, about 35 ft. wide, 99 ft. long and 60 ft. high, of buff brick and steel construction with generous window space, and a plant which is a model of compact design, operating convenience and provision for expansion. Turbine and boiler are in the same room as shown by Fig. 2 with the turbine centrally located with sufficient space for a second and third unit on either side. In case additional capacity is needed, the new boiler or boilers will be located in space now occupied by the old boilers.

Figure 2 was taken from the corner of the electrical bay looking toward the boiler, the top portion of which is visible over the triangular coal hopper for the pulverizers. A Richardson automatic coal scales, about half of which is visible on the balcony at the extreme left of the picture, serves both pulverizers and is mounted on wheels so that it can be moved to give access to the feeder hoppers. Coal bunkers and hoppers are amply provided with inspection doors and poke holes (one of these is visible just to the left of the turbine governor and back of the hand rail), in case of bridging of the coal. This is a small point but typical of the thought and care that has been taken to insure continuity of operation.

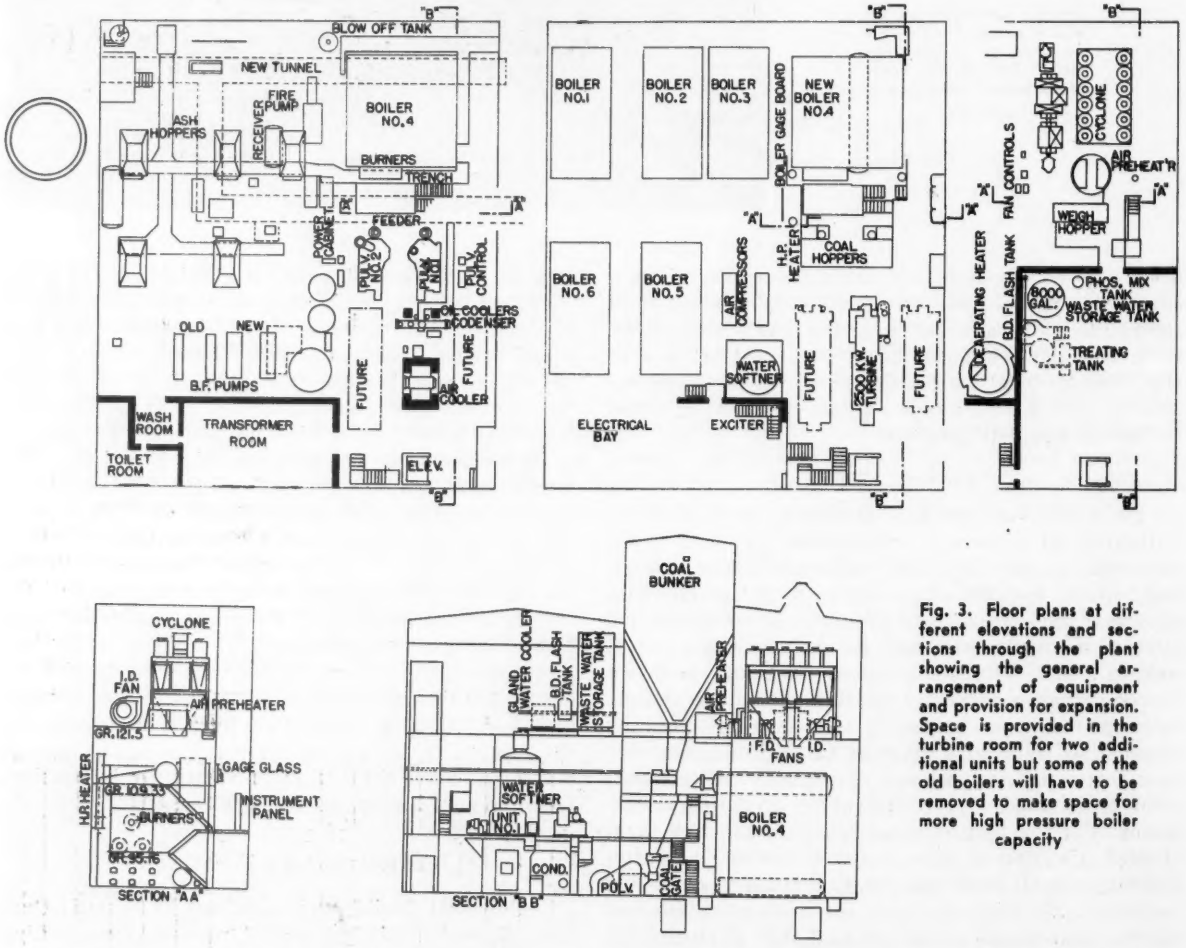


Fig. 3. Floor plans at different elevations and sections through the plant showing the general arrangement of equipment and provision for expansion. Space is provided in the turbine room for two additional units but some of the old boilers will have to be removed to make space for more high pressure boiler capacity

Both the Smoot boiler control panel and the Allis-Chalmers turbine panel are located on the main operating floor between the boiler and turbine where the operator has a clear view of practically the entire plant. Pulverizers are located on the ground floor immediately under the coal scales and in front of the boiler. Figure 5 is a view taken from the boiler front just below and in the opposite direction from Fig. 2.

The boiler is of the Babcock & Wilcox integral furnace type with 10,800 sq. ft. of boiler surface and 1630 sq. ft. of water wall surface around a 4916 cu. ft.

furnace. It has a continuous rating of 100,000 lb. per hr. of 650 lb., 720 deg. F. steam. Each pulverizer and its 4300 c.f.m. fan is driven by a 75-hp. motor through a V-belt drive. Feeders are driven by ½ hp. constant speed motors through variable speed drives and under the control of Bailey coal level panels which unfortunately are just beyond the right and left hand borders of Fig. 5 but clearly shown in the basement plan, Fig. 3. To give flexibility at part load operation, one pulverizer supplies one burner and the other supplies two burners.

Perhaps the most novel features of the plant are found on the fan floor above the boiler as shown in plan, Fig. 3 and by the photograph, Fig. 4. Both the Clarage forced and induced draft fans are mounted on the same shaft and are dual driven. A 165-hp. Terry geared turbine drives the combination at heavy loads up to the maximum rated speed of 1248 r.p.m. At the opposite end of the shaft is a 900 r.p.m., 100-hp. motor equipped with a Morse Chain Co. free wheeling clutch. This is used at lower loads when it is desirable to get maximum output from the main generator and take advantage of the difference in performance between it and the comparatively small fan turbine.

The forced draft fan has a maximum capacity of 32,000 c.f.m. of 80 deg. F. air at 6.1 in. of H_2O and discharges downward through an adjacent 9500 sq. ft. Ljungstrom air heater to ducts down the front of the boiler to the burner windbox. The induced draft fan with a maximum capacity of 52,000 c.f.m. of 350 deg. F. gas at 9.3 in. of H_2O takes its suction from dust collecting system and discharges through a breeching to a 12 ft. diam. stack extending 180 ft. above the operating floor.

Flyash Removal

Because the plant is located adjacent to a residential neighborhood the matter of flyash was given careful consideration and a Prat-Daniel multiple cyclone system of dust removal installed. This consists of 12 cyclones, each 3 ft. in diam. and 11 ft. long and provided with a 5 by 5 ft. bypass normally kept closed. In addition 10 of them have adjustable dampers automatically controlled to maintain a constant pressure loss through the system at all boiler loads down to the minimum. The two dampers insure a clear passage to the stack at all times and guard against accidental complete closure of the gas passage. A number of tests made of the equipment in service indicated a removal of from 87 to 94.5 per cent of solids detectable by a porous thimble. The bulk of the collected material is shown by microphotographs to be minus 325 mesh.

The Allis-Chalmers turbine is rated at 2500 kw., or 3570 kv-a. at 70 per cent power factor, 4800 v., 3 ph., 60 cycle and is equipped with a 16 kw., 125 v. direct connected exciter. Throttle conditions are 650 lb. pressure, 720 deg. F. total temperature. The power factor of the plant is, however, high, running approximately 90 per cent and maximum loads of over 4000 kw. are common. Typical days during the summer show from 55,000 to 69,000 kw-hr. generated with from 12,000 to 15,000 kw-hr. purchased.

Figure 6 shows a single line diagram of the electrical system in the power house. The arrangement is such that any part of the load can be carried either by the company or by the utility system. Feeder circuits are all 480 v. Power house auxiliaries, which in common with all other plant motors, operate at 440 v. and are supplied from feeder No. 6 through an auxiliary cabinet located on the operating floor. A spare 20-kw. motor driven exciter has been provided for emergency service.

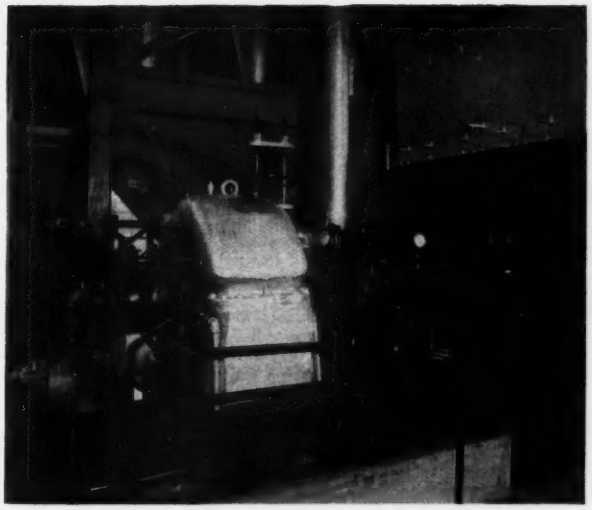


Fig. 4. Induced and forced air draft fans are mounted on the same shaft and dual driven. This is a view from the induced draft fan end. The motor is on the opposite end of the shaft and drives the fans at lower loads through a free wheeling clutch. The bottoms of the multiple cyclone dust separators preceding the induced draft fan are visible over the turbine

Although Battle Creek water is comparatively hard, about 18 gr. per gal. and high in incrusting solids, the Cochrane lime and soda ash treatment with the Hall System of supplementary phosphate, sulphite and sulphate feed to the boiler has been entirely effective. Close control of boiler water conditions is maintained and special precautions taken to see that samples are taken at such a time and place as to give reliable results. Returns, including that from the factory run about 60 per cent and are collected in an underground hotwell and pumped to the deaerating heater. Makeup is taken from the factory well water system through

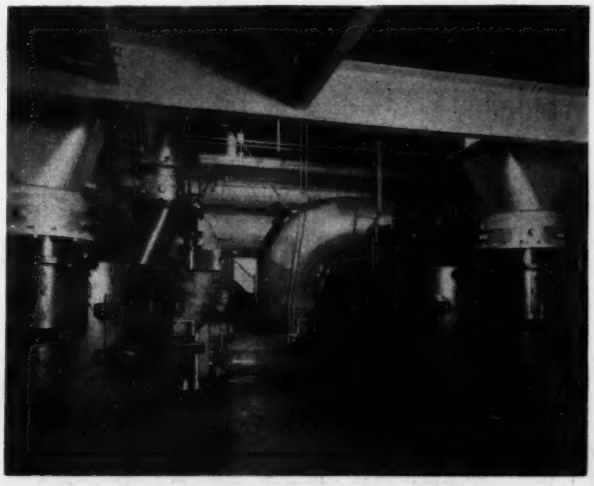


Fig. 5. Either of the two pulverizing mills, located just in front of the boiler, can carry 75 per cent of full boiler load if necessary. The end of the condenser is just visible at the left of the stairs in the center of the picture

the generator air coolers, and continuous blow down heat exchangers into the lime and soda ash softener. The continuous blow down flashes at 10 lb. to the deaerating heater and the remaining water passes through a heat exchanger where it is cooled by the incoming makeup. Additional steam for feedwater heating and treating is taken from the 10-lb. system.

Feed Pumps

From the deaerating heater and treated water storage, the feed pumps take their suction at 240 deg. F. and pump through a 408 sq. ft. Alco vertical high pressure heater to the boiler through Stets feedwater regulators. This heater is supplied with 125 lb. saturated steam and the feedwater reaches the boiler at about 340 deg. F. Each of the two Worthington centrifugal boiler feed pumps are rated at 340 g.p.m. of 240 deg. F. water at 1700 ft. head and 3550 r.p.m. and are driven by 175-hp. Terry turbines.

For the new boiler the old coal handling equipment was utilized. Coal is unloaded into a track hopper and fed by a belt conveyor through a crusher to a bucket elevator. From here it may be delivered over a flight conveyor to a 1000-t. storage or to the bunkers in the plant. The old bunkers have a capacity of 600 t. and the section added for the new boiler 250 t. For the old boilers it is then distributed by a weigh larry but for the new boiler it feeds by gravity through the coal scales to the mill feeders. Coal can also be supplied to the high pressure boiler from the old bunker by means of a Stephens-Adamson Redler conveyor that runs from the old bunker and discharges to the new bunker. Ash and dust are handled by a United Conveyor Co. steam jet system to an outside ash tank.

At present a zero to 5/8-in. Elkhorn slack with a Hargrove grindability of about 62 and an ash fusing temperature of 2200 deg. F. is being burned. The moisture averages about 5 per cent and the ultimate analysis on a dry basis in percentage is: C, 80.21; H, 5.30; N, 1.45; S, 0.59; ash, 5.50; O, 6.95; B.t.u. per lb., 14,350 This coal was selected after making a comprehensive determination of the use factor of some 68 coals and an actual trial of the three lowest. It is of interest to note that the use factor studies gave this coal the highest rating before confirmation by actual combustion tests.

Average monthly boiler efficiencies range around 85 per cent and the power consumption of the mill,

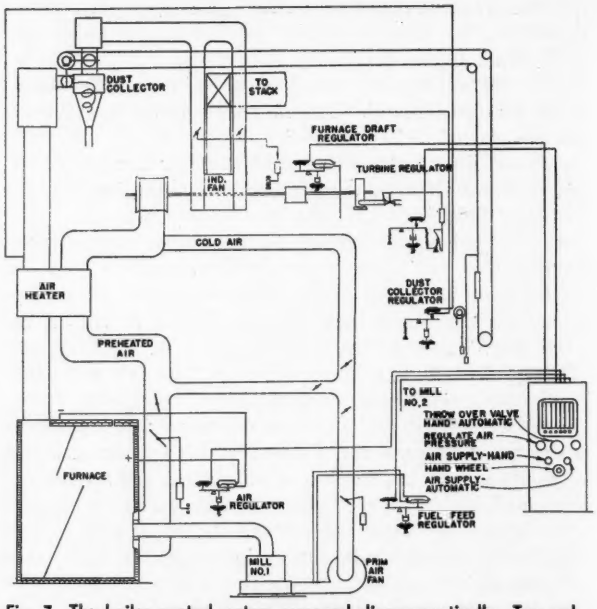


Fig. 7. The boiler control system arranged diagrammatically. Two pulverizers are installed but for simplicity only one mill is shown above. The cyclone regulator is independent of the combustion control and maintains a constant pressure drop across the dust collecting system. Coal feeders are controlled from the mill coal level

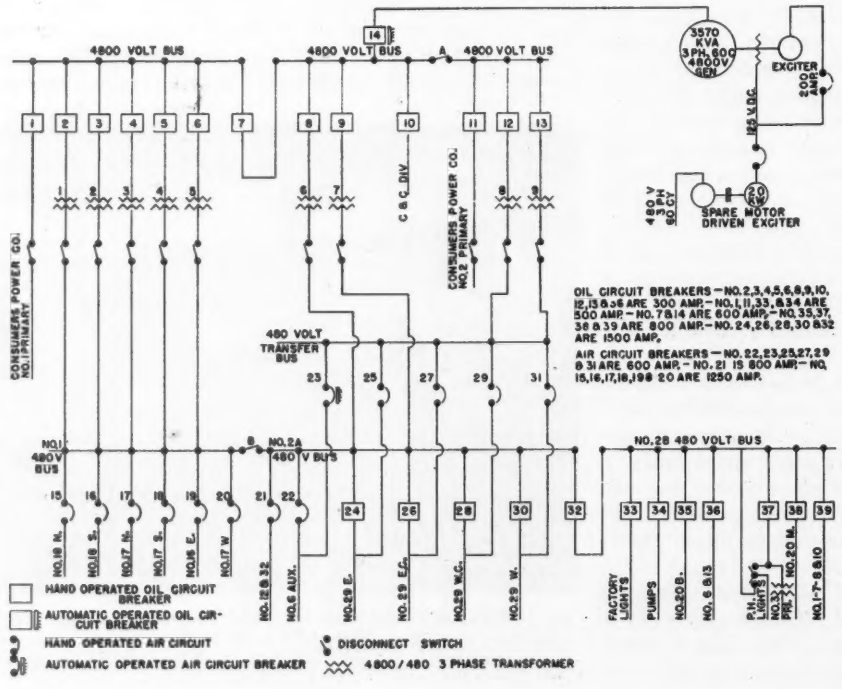

4800 VOLT BUS
4800 VOLT BUS
4800 VOLT BUS
3570 KVA 3PH. 60C 4800V GEN
EXCITER
125 V.D.C.
480 V 3PH 60 CY
SPARE MOTOR DRIVEN EXCITER
CONSUMERS POWER CO. NO.1 PRIMARY
C & C. DIV.
CONSUMERS POWER CO. NO.2 PRIMARY
480 VOLT TRANSFER BUS
OIL CIRCUIT BREAKERS — NO. 2,3,4,5,6,8,9,10, 12,13 & 36 ARE 300 AMP. — NO. 1, 11, 33, & 34 ARE, 500 AMP. — NO. 7 & 14 ARE 600 AMP. — NO. 35, 37, 38 & 39 ARE 800 AMP. — NO. 24, 26, 28, 30 & 32 ARE 1500 AMP.
AIR CIRCUIT BREAKERS — NO. 22, 23, 25, 27, 29 & 31 ARE 600 AMP. — NO. 21 IS 800 AMP. — NO. 15, 16, 17, 18, 19 & 20 ARE 1250 AMP.
NO.1 480V BUS
NO.2A 480 V BUS
NO.2B 480 VOLT BUS
NO.18 N.
NO.18 S.
NO.17 N.
NO.17 S.
NO.16 E.
NO.17 W.
NO.12 & 32
NO.6 AUX.
NO.29 E.
NO.29 E.C.
NO.29 W.C.
NO.29 W.
FACTORY LIGHTS
PUMPS
NO.20 E.
NO. 6 & 13
P.H. LIGHTS
NO.33 PRESS
NO.20 M.
NO.1-7-8.10
HAND OPERATED OIL CIRCUIT BREAKER
AUTOMATIC OPERATED OIL CIRCUIT BREAKER
HAND OPERATED AIR CIRCUIT
AUTOMATIC OPERATED AIR CIRCUIT BREAKER
DISCONNECT SWITCH
4800/480 3 PHASE TRANSFORMER

Fig. 6. Single line electrical diagram. The arrangement is such that any part of the load may be carried either by the company or by the utility system

Operating sequence of the interlock system shown by Fig. 8

The starting sequence is as follows:

1. Obtain 110 v. a.c. control supply by closing safety switches (not shown on this drawing).
2. Start the induced draft fan. After sufficient induced draft has been built up, the mercury draft switch ID.SW. will close and energize the induced draft relay IDR.
3. It will now be possible to latch open the forced draft damper. Failure of the induced draft at any time will de-energize IDR and cause the solenoid FDDS to trip the forced draft damper. There are two trip solenoids for this damper, one for each pulverizer or control circuit.
4. After sufficient forced draft has been obtained, forced draft relay FDR will be energized through the mercury switch FD.SW.
5. If the coal feeder switch is in the off position, ignition relay IR will cause the red blinker lights to flash and signaling the need of ignition.

5a. Apply ignition.

6. Pulverizer motor can now be started by push button PB.
7. Coal feeder can now be started by placing coal feeder switch in either "hand" or "automatic" position.
8. After coal feeder motor has been started the pulverizer damper can be latched open. Stopping the pulverizer at any time will cause the pulverizer damper to trip shut.
9. When the foregoing operations are completed ignition signaling blinker lights will stop but will restart if the coal feeder switch is turned to "off" position, or, if the pulverizer damper is closed while the fans are running.

In case of automatic shut down of any of the equipment, the interlock system will operate as follows:

1. Failure of induced draft will open the induced draft switch ID.SW. and de-energize the induced draft relay IDR. This operation will trip the forced draft damper shut, stop the pulverizer, trip the pulverizer damper shut and stop the coal feeders.
2. Failure of forced draft will open the forced draft switch, FD.SW. and de-energize the forced draft relay FDR. This will stop the pulverizer, trip the pulverizer damper shut and stop the coal feeders.
3. Failure of the pulverizer will stop the coal feeder and trip the pulverizer damper shut.
4. Failure of the coal feeder affects only the coal feed.
5. Loss of voltage will shut down the pulverizers and coal feeders. It will also cause the loss of the fans if they are being motor driven at the time. On resumption of voltage it will be necessary to restart in the manner prescribed in starting sequence. The fan motor will not restart automatically.

mill fan and feeder motors range from 20 to 23.4 kw-hr. per t. for average loads. So far the mills have operated about 7200 hr. each with comparatively little wear, the balls having worn from an original diameter of 9¼ to 8⅞ in. Tests show the fineness to range from 87 to 92 per cent through 200 mesh and combustible in the ash from 20 to 25 per cent.

Complete automatic control by the Smoot System has been provided from a boiler control panel located on the operating floor above the mills. This, well shown by the diagrammatic drawing Fig. 7, incorporates the usual master responsive to steam header pressure. This master controls five regulators: two for fuel control to the boiler; one in the primary air line to each mill; one for air supply to the boiler by a duct damper; one for gas flow from the boiler by a duct damper; and one for fan speed. The loading pressure on these regulators is balanced by a pitot tube in the primary air duct for fuel supply; by the draft loss across the boiler for air flow; and by the furnace pressure for the gas flow. Coal feed to the mill is independently regulated by a Bailey mill level controller and the operation of the cyclone dampers by a separate Smoot regulator which maintains a constant pressure drop across them as explained earlier.

Fan Speed Control

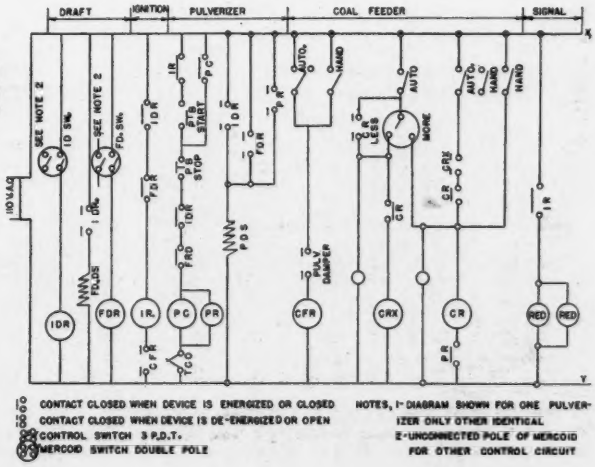
This cutting of cyclones in and out of the gas path makes necessary some provision to readjust the loading pressure to the fan regulator in relation to the secondary air and furnace pressure regulators. The problem is further complicated by the fact that both fans are on the same shaft, revolve at the same speed and have a combination of damper and speed regulation. Both the air and gas damper operating cylinders are equipped therefore with electrical contactors, arranged so that when, under the influence of the master loading pressure, the dampers approach the open or closed position a small reversing motor is energized to operate a leak-off valve in the loading line to the fan speed regulator and keep the dampers within a regulating range of between 20 and 80 per cent open.

If for instance the damper in the air duct opens to 80 per cent the motor operates to close the leak-off valve, increase the effective loading pressure on the fan regulator and speed up the turbine. The increased flow will then cause the regulator to move the damper back into the regulating range, breaking the contact and stopping further action of the bleed valve. Under certain conditions, one damper may be operated at near the wide open position while the other may be making contact to open the bleed valve to decrease the fan speed. For this reason the wiring is so arranged that both dampers must be calling for a decrease in fan speed before it can be obtained.

Although the operator is indispensable and can do much that automatic equipment cannot do, safety protection of modern plants is entrusted to automatic devices incorporated in an interlock system. A diagrammatic arrangement of the Hagan interlock system in this plant is shown by Fig. 8 and a complete description of the starting and stopping sequence is given by the table.

Fig. 8. Schematic arrangement of the interlock system entrusted with the safety of the boilers in emergencies and on starting. Abbreviations shown on the drawing or used in the table above are given below

TCO—Thermal cut out.
CF—Coal feeder.
CFR—Coal feeder relay.
CR—Coal feeder motor contactor.
CRX—Coal feeder motor cont. release.
FDR—Forced draft relay.
FD.SW—Forcer draft switch.
FD.DS—Forced draft damper solenoid.
ID—Induced draft
IDR—Induced draft relay.
ID.SW—Induced draft switch.
IR—Ignition relay.
L—Ind. light.
PB—Push button.
PC—Pulverizer contactor.
PR—Pulv. relay.
PDS—Pulv. damper solenoid.



The Index method was developed by Forrest Nagler to determine the efficiency curve of low heat turbines. Values obtained are only relative but they do show the relation between characteristics at various gate openings. The method described in this article represents a further development of the Index method in which the water is actually measured at or near the most efficient gate opening as determined in the Index test.

INDEX TESTING
For Low Head Hydro Plants

By Donald H. Mattern

IT HAS BECOME increasingly desirable to completely utilize all the water passing through hydro plants. The steady decrease in cost of producing electrical energy by steam motivated turbines has made this imperative. To use the latent energy in the falling water to the best advantage, the turbines must be operated in the most efficient manner. This can only be done if their characteristics have been determined and such information applied to normal operation.

Testing by standard means is relatively expensive when applied to small units. The cost also prohibits desirable test work upon many units when more emphasis is placed upon actual dollar outlay than upon elimination of wasted energy. It is under these conditions that the method of Index Testing is especially applicable.

This method was developed by Forrest Nagler who, after study of numerous tests and experiments upon low head units, presented this means to determine the shape of the efficiency curve. Values taken from it are only relative, but they do show the relation between characteristics at different gate openings. The method, therefore, gives an accurate index of unit operation.

The Index theory presents a new approach to the subject of turbine testing. By standard methods the velocities throughout the cross-section of the intake are integrated to secure an average velocity for use in quantitative computations. The Index theory makes no use of such average values, but only the relationship which exists between the velocities at one definite location and the corresponding unit discharges. It is based on the fact that the water velocities in a turbine water passage correspond to definite quantities of flow, and will vary in direct ratio with these discharges. Velocities at other points in the section will be different numerically, but the ratio of partial

Test No.	Test Time	Ind. Gov.	Actual Gate Inches	Unit Head-water	Outside Tail-water	Eff. Head	Current Meter Rev.	Current Meter Time-Sec.	Vel. Ft/Sec
	AM								
1	10:34	F.G.	10.41	691.13	636.20	54.93	20	14.14	2.46
2	10:45	90	9.15	691.10	635.90	55.20	20	15.49	2.25
3	10:55	80	8.05	691.09	635.80	55.29	20	17.05	2.04
4	11:02	75	7.54	691.08	635.70	55.38	20	18.24	1.92
5	11:32	70	7.00	691.02	635.60	55.42	20	19.25	1.82
6	10:18	65	6.44	691.18	635.60	55.58	20	17.30	2.02
7	11:40	65	6.44	691.00	635.60	55.40	20	20.52	1.71
8	11:48	60	5.90	691.00	635.55	55.45	20	21.67	1.62
9	12:00N	50	4.84	691.00	635.40	55.60	10	13.27	1.33
10	12:07	40	3.82	691.00	635.25	55.75	10	15.97	1.12
11	12:13	30	2.86	691.00	635.00	56.00	10	19.40	0.92

Governor Dial was at 101% when at Full Gate
Current Meters located at Elev.680.8
No.3 Unit operated at 67% governor throughout the test

Table giving head and discharge data obtained in tests on Plant A

to full gate velocities will be the same. Locations for index determinations, of course, must be chosen where there either is no pulsation or it is reduced to a minimum. The period of a single observation must consequently be of such duration that the entire cycle is definitely covered.

Discharge at one gate opening is computed by use of the recorded output, measured head, and an estimated efficiency. The water index-gate opening relationship enables the discharges at other gates to be computed, and from these the overall and turbine efficiencies. If the maximum does not occur at the estimated gate opening, another estimation is made and the process repeated.

Further Developments

More recent tests run on different plants in the Middle West by R. A. Garrett and his assistant, the writer, form the basis for deviations from the method first suggested by Mr. Nagler. In these tests current meters were used exclusively as the index meter and absolute values, instead of relative values, are obtained within close limits. The difference is that in these newer tests the water is actually measured at or near the most efficient gate opening as determined in the Index test, whereas no measurement is made in the Nagler method. Discharges at other gates are secured by use of the water velocity curve.

Because water discharge at the same inches of gate opening varies but little throughout the life of a turbine, there are also times when it may be possible to tie in discharges from previous tests with the newer ones without actually measuring the flow. Judgment and experience in testing, however, are essential to this procedure.

Plant A presents an Index test of the latter type where the data were tied in with a very comprehensive current meter test which had been conducted upon on of three 100 inch diameter, 100 r.p.m., 7500 br.hp. vertical units.

Preliminary observations showed that some angularity of flow existed so the propeller and Price type current meters were placed close together (2 ft. apart) and at the same elevation. From cross-sectional drawings of the intake it was thought that best flow conditions would occur between 10 and 14 ft. below the water surface. Actual explorations of the vertical showed that the most even flow existed at 10.5 ft.

Observations were made at full gate, 90, 80, 75, 70, 65, 60, 50, 40, and 30 per cent openings. Output curves had shown that the point of maximum efficiency probably occurred between 60 and 80 per cent, and readings were consequently taken at .05 intervals between these two points. The lowest run was limited by erosion in the tailrace which made it impossible for No. 2 unit to seal below 30 per cent gate. Summary of the field data are in the accompanying Table.

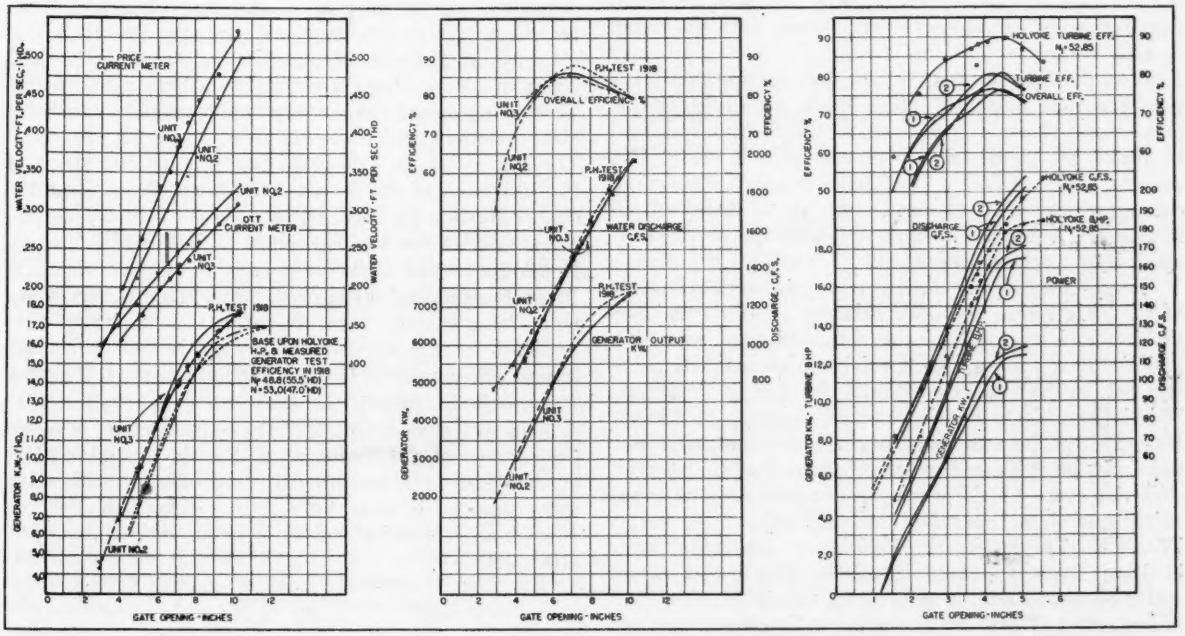


Fig. 1. Curves for Plant A, Units Nos. 2 and 3. Water velocities and generator kw. at 1.0 ft. head. Based upon generator output measured with laboratory instrumen'ts, and water velocities obtained by Price and Ott current meters

From Fig. 1 it will be noted that the observations with the Ott meter were much more consistent and followed a definite rule much more closely than did those of the Gurley Price meter. As would be expected when one considers the transverse flow which was found to exist at the intake, the Price meter results also show a consistently higher water velocity. Characteristically, the propeller type meter registered primarily only that velocity parallel to its axis whereas the turbine type meter registered flow from all directions. The Ott meter evidently gave more reliable values of water velocity and these points were the only ones used in further computations.

It is noted that the full gate output of 7420 kw. for No. 3 Unit was exactly the same in both tests. (Fig. 2) In all probability the same discharge had

occurred at both times, and this seemed to be an ideal point at which to tie them together.

The 1918 full gate discharge of 1970 c.f.s. was taken as the full gate discharge in this Index test, and flow at other gates were pro-rated by use of the water velocity curve.

STUDY OF RESULTS—The test in 1918 was conducted at an average head of 47 ft., or a unit speed of 53.0; the Index test, however, was at 55.5 ft., equivalent to a speed of 48.8. The shape of the 1918 output curve (Fig. 1) conforms to the shape of the Holyoke power curve for the unit speed applying at that time. The latest output curve also conforms to its Holyoke speed, with the performance differences occurring as would be expected. From Fig. 2 it is seen that the discharge curve obtained for the Index test agrees very closely with that secured for the No. 3 unit in 1918. The early test gave slightly greater values at gate openings between 60 per cent and full gate, but since higher power readings were obtained, the differences between the discharge curves are consistent. It is almost certain that if the elaborate 1918 test was repeated the discharges would agree very closely with the Index results.

ECONOMICS—The testing of the units took two days time for four men; the office work an additional 50 man-hours. This is compared to the 6 days required to make the field test upon one unit in 1918. No records are available to give details concerning computations of that test, but it is believed 50 man-hours would be a minimum estimate of the time needed to work up the data.

Total cost of the Index test was approximately $200. This figure includes salaries of the four men making and working up the test, and their traveling and living expenses. No special equipment had to be secured, so that no expense was charged to that item. It is impossible to obtain the cost of the power house test of 1918 because accurate records had not been kept. It is quite conservative to estimate, however, that the cost of field work on one unit was as great as the complete Index test on both units.

PLANT B—The test of the 4000 Br.hp. horizontal units in Plant B is an example of the Index test where water measurement is made. In this plant one unit is composed of four 44-in. horizontal runners mounted upon one shaft driving a directly connected generator. These units had never been field tested, although Holyoke tests had been run upon a model in a vertical setting. The set-ups were not homologous and the data were not strictly applicable.

The Plant B intake consists of two distinct bays of 3 sections each, the total net intake width being 42 ft. Preliminary investigations revealed no appreciable cross flow or eddy currents except at the extreme left of the left section. Here there was some disturbance but not sufficient to affect the Index results. Because of the relatively large intake width it was decided to use three current meters in order to secure accurate Index readings. One Ott was located in the middle of the right bay, another Ott in the middle of the left bay, or Section 5, and the Price in Section 4, all of them being placed 5 ft. below the water surface.

After completing the Index tests the discharge of No. 2 unit was measured at 90 per cent governor indicator. Two racks were constructed and one Ott meter arranged for use with each one. Four verticals were marked off on each rack according to the Tchebycheff division, with an extra point in the extreme left section where cross flow existed. Using five readings on each vertical (also located by Tchebycheff ordinates) the total number of observations was 125. Approximately 6 hr. was required to take readings at all locations.

The difference between current meter technique for the two types of tests should be noted. In the Index test a large number of readings were taken at relatively few points. In the water measurement test, a few readings were taken at a large number of points, and by their quantity reduced the relative weight to be given each average figure. In this case, current meter readings were taken over a period of approximately 2 minutes; in the Index test they were taken over a period of 10 minutes.

STUDY OF RESULTS—The efficiencies, discharges, and power outputs of the test, together with Holyoke data applicable thereto are plotted on Fig. No. 3. It is noted that the test outputs are lower and the discharges higher than those obtained upon the model at Holyoke. The outputs of the actual power house installations, and the resulting turbine efficiency are probably less than that obtained at Holyoke because of the variables brought about by change from a vertical to a horizontal setting. This change more than offsets the usual power and efficiency step-up which results from model to prototype. The curves for the two units have the general shape of the Holyoke and are consistent to them. No. 2 Unit discharge seems a bit high, but the output is also high and apparently causes the variations as indicated.

ECONOMICS—The cost of testing these two units in Plant B amounted to approx. $300. This differs somewhat from that of Plant A because of the extra time required for the water measurement in the field, office computations relative thereto, and an unusual test set-up.

CONCLUSIONS—Results of these tests are believed to demonstrate the usefulness of the Index Method in securing performance characteristics. For the many low head, small plants built integral with the dam, or with small units mounted in open flume setting, this method should furnish an economical means of obtaining reliable operating data.

NICKEL ALLOY STEELS have, during the past year, affected practice in practically every branch of industry. Because of greater strength and toughness, lighter weight in structures and machinery has been possible including buildings, bridges, cars, dredges, and locomotives. Hand tools, such as wrenches and chisels, can be smaller for inaccessible locations, aeroplanes are lighter and with less air resistance. Harder rolls for rolling mills are available, non-corrodible valves are used for pipe lines and non-rusting floor plates for boats. Non-magnetic clamps are utilized for bus bar joints, shafting and wearing sleeves are made lighter and have longer life, pump cylinders and linings are less porous against high pressures, boat hulls are protected against corrosion and fouling is reduced. Hard nickel covering is plated on which requires no buffing and resists wear, use for condenser tubes has increased. Strangely, one alloy, Ni-Resist, is non-magnetic, while another, Alnico, has unusually high permeability so that the high magnetic flux allows of constructing very compact magneto units.

It is not necessary to know all about the mechanical details of various makes of turbines in order to select the proper steam conditions and turbine for a particular application. What is necessary is a sound understanding of the fundamentals of steam flow and the availability of energy. In this third article of Mr. Newman's series he discusses these fundamentals in a simple understandable manner.

MODERN TURBINES*

By
L. E. NEWMAN
Turbine Div. General Electric Co.
Lynn, Massachusetts

IT IS A STRANGE PARADOX that two turbines made by the same manufacturer may have identical ratings, speeds, and efficiencies yet one may be more than twice the physical size of the other, and require a greatly different quantity of steam flow to develop its rated output. It isn't a question of the designer's change in ideas, but simply illustrates that the initial and final steam pressures are as important as the rating in determining the physical size and steam rate of a turbine. For a given rating and type of turbine these two pressures, inlet and exhaust, determine the size passage required to admit the steam, the size opening required to exhaust it, the number of stages needed to get the most power out of the steam, and the number of pounds of steam required to generate a given unit of power.

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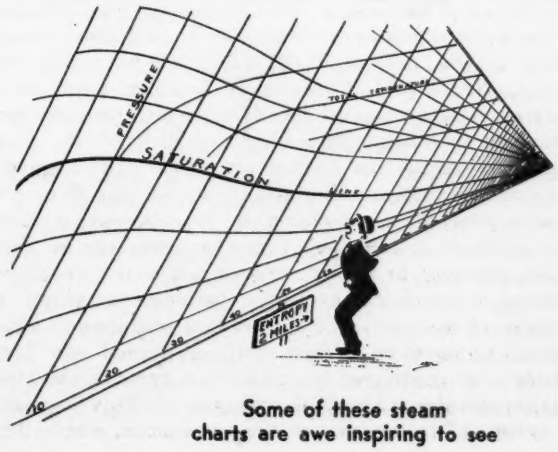


Some of these steam charts are awe inspiring to see

Considerations of speed and efficiency modify the design, but no other factors having to do with the selection, economy, and size of a steam turbine are as important as the steam conditions. (With all other conditions the same, the rating would become the controlling factor in physical size.) Why is this so?

Primarily it is true because steam is elastic, expanding with decrease in pressure. One pound of steam, for example, at an absolute pressure of 2000 lb. per sq. in. will occupy a space of less than 2/10 of one cubic foot. At an absolute pressure of ½ lb. per sq. in. this single pound of steam would occupy a space of more than 600 cu. ft. An increase in specific volume (cu. ft. per lb.) of over 1000 times! Obviously, then, pressure has much to do with the size of the steam passages through a turbine.

But the amount of space occupied by steam at different pressures is only one of the factors. A factor, just as important as the first, is the ratio of the inlet pressure to the exhaust pressure for this is an approximate measure of the amount of energy in the steam available for conversion into power. The greater the ratio of inlet pressure to exhaust pressure the more energy available for conversion into power, and the more energy available the more stages[1] will be required in the turbine efficiently to convert this energy into power. Also, as more energy is available for conversion into power from each pound of steam fewer total pounds of steam will be required by the turbine to develop its rated output. So the ratio of the inlet pressure to the exhaust pressure has much to do with fixing the physical size of a turbine by its effect on the number of stages (length) and its effect on the steam flow (area).

[1]Assuming no increase in design speed, "more stages" may mean numerically more, or stages of larger diameter.

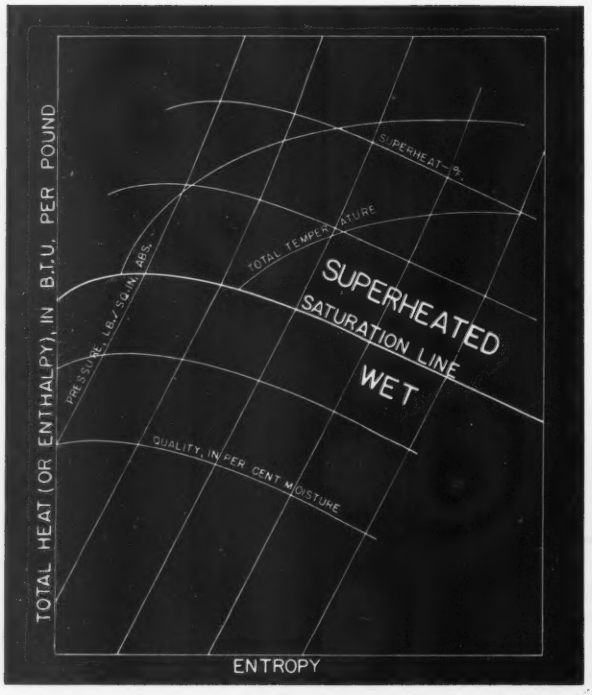


Fig. 1. Steam Chart (Mollier Diagram)

To use this information to advantage in selecting the turbine best fitted for present and future requirements, and estimating the performance of that turbine, it is not necessary to know how to design a turbine. Certain fundamentals affecting the design of turbines are so basic that they apply to impulse, reaction, radial flow, geared, or whatnot. With a sound knowledge of these fundamentals any engineer having only the vaguest ideas of the internal appearance of a turbine can do much in making preliminary studies of their application and performance. Before a turbine is actually bought the purchaser will probably carefully scrutinize the experience, service facilities, and turbine design of the different manufacturers, and from these and other weighty factors determine his choice of the builder. But without a knowledge of these factors he can select the best steam conditions, the rating, and type of turbine to suit best his particular application. The important thing is to understand the fundamentals of steam flow and availability of energy.

These fundamentals are surprisingly few. Knowledge of mysterious terms such as entropy, while helpful, is not necessary for the average engineer. Each of the essential fundamentals has a physical significance easy to understand and apply. For example, much confusion attends the use of the steam chart, which is neither difficult to understand nor hard to use.

Complete steam charts, known as Mollier diagrams, range in size from no larger than a page of this magazine to those used by the turbine manufacturers 16 ft. long. They are awe inspiring to see, but their fearsome appearance belies their simplicity. In Fig. 1 a section of the conventional steam chart has been reproduced with all of the entities appearing on the usual commercial charts. The only simplification made in this chart has been the omission of intermediate pressures, temperatures, etc., which minimize interpolations on the usual diagrams.

Steam charts give certain properties of steam on a per pound basis over a wide range of steam conditions. The vertical scale gives the total number of heat units ("enthalpy" is the engineering term) in B.t.u. per lb. The horizontal scale is "entropy", a convenient reference line for expansion of steam in an ideal turbine.

Steam pressures are shown on a series of nearly parallel lines in terms of pounds per sq. in. *absolute* (Abbr. lb. per sq. in. abs., or A.). Commonly pressures are expressed in lb. per sq. in. *gage* (Abbr. lb. per sq. in. g.), but all steam charts and all physical relations of pressures are expressed in pounds absolute. To convert lb. per sq. in. gage to lb. per sq. in. absolute, it is

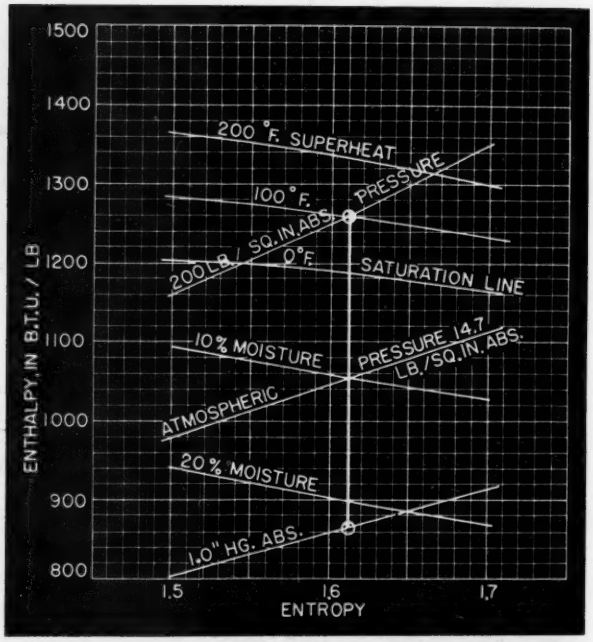


Fig. 2. A portion of an actual steam chart

only necessary to add to the gage pressure the atmospheric pressure. At sea level atmospheric pressure is 14.7 lb. per sq. in. (usually taken as 15 lb. per sq. in.), so the question for correcting gage pressures at or near sea level to absolute pressures is

lb. per sq. in. g plus 14.7 = lb. per sq. in abs.

When pressures are less than atmospheric (vacuum) they may be expressed in lb. per sq. in. abs. or as is usually done, in terms of the height of a column of mercury. With a perfect vacuum at the top of a column of mercury the normal sea level atmospheric pressure will support the column at a height of 30 in. With a less perfect vacuum the normal air pressure will support the mercury column at a height, say, of only 28 in. So pressures below atmospheric may be expressed as vacua in inches of mercury, or, better, expressed as an absolute pressure in the same units. The difference between atmospheric pressure (barometer reading, in inches of mercury) and the vacuum reading will equal absolute pressure. Thus with a normal sea level barometer reading of 30 and a 28 in. vacuum, the absolute pressure will be 2 in. of mercury. This is usually expressed 2 in. hg. abs., or, for convenience, simply 2 in.

Whenever pressures are expressed as a vacuum they are meaningless unless referred to the barometer reading. The normal barometer at sea level is 30 in.; becoming less with increasing altitude. Consequently expressing exhaust pressures in terms of vacua referred to the barometer is more cumbersome and more likely to introduce errors than using the simple and more definite absolute pressure expressed either in lb. per

Table. Condensed table of specific volume of steam in cubic feet per pound at various pressures.

PRESSURE in #/SQ." ABS.	SPECIFIC VOLUME IN CU. FT./LB. WITH A SUPERHEAT OF 0 DEG. F.	200 DEG. F.
0.5	641	880
1	334	453
2	173	234
10	38	50
20	20	26
100	4.4	5.8
200	2.3	3.0
1000	0.4	0.6
2000	0.2	0.3

sq. in. abs., or preferably in inches hg. abs. The steam chart has lines of constant absolute pressures in lb. per sq. in. over the entire range supplemented in the lower region by lines of constant absolute pressures in inches hg.

Note that the upper and lower regions of the steam chart are separated by a line known as the "saturation" line. The significance of this can be understood by considering a pound of water being gradually heated in an enclosed space maintained at a constant pressure of 14.7 lb. per sq. in. abs. (atmospheric pressure at sea

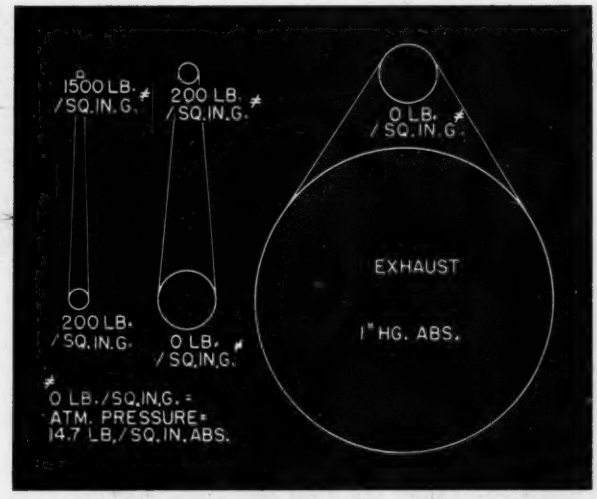


Fig. 3. Relative size of turbine inlets and exhausts for turbines designed for different steam conditions but having identical ratings and substantially the same ratings

level). Then as heat is added the temperature of the water will be raised until it reaches 212 deg. F.; the boiling point for that particular pressure. More heat will not raise the temperature until all of the water is vaporized. When enough heat has been added to just vaporize all of the water the vapor is said to be dry and saturated. Conversely, if any heat were withdrawn from the vapor at the saturation line partial condensation will occur, and the vapor will be no longer dry. The vapor may have minute particles of water suspended in it, and the quantity of water so held in suspension may be expressed as a percentage of the dry state, or as a percentage of the completely wet state. Thus steam may be said to be 2 per cent wet, or, stated another way, 98 per cent dry.

After sufficient heat has been added to convert all of the water into dry and saturated steam further additions of heat will raise the temperature. Steam having its temperature so increased is said to be "superheated." The difference between the saturation temperature of the steam at a given pressure, and its temperature as read by a thermometer is the superheat of the steam. In equation form these three temperatures are related:

Deg. F. superheat = deg. F. total temp. — deg. F. saturation temp.

Lines of constant total temperature, and lines of constant superheat appear on the steam chart. The saturation temperature for any pressure is shown by the intersection of a total temperature line with the saturation line at that particular pressure. Steam at a pressure and temperature above the saturation line on the steam chart is superheated; steam at a pressure and total heat below the saturation line contains moisture and is said to be wet. But the temperature of steam in the wet region of the chart is the same as the saturation temperature at its particular pressure.

It should be especially remembered that a relatively small quantity of heat is required at usual pressures to bring water to its boiling temperature, but that several times this quantity of heat is needed to change the water into dry steam at the same temperature. Likewise when the steam is returned to water the bulk of its heat must be given up. Insofar as the use of steam in turbines is concerned, this property of water vapor has great significance.

Steam turbines convert heat energy in the steam into work, but only a relatively small portion of the heat in the steam can be converted into work by any turbine regardless of its efficiency.

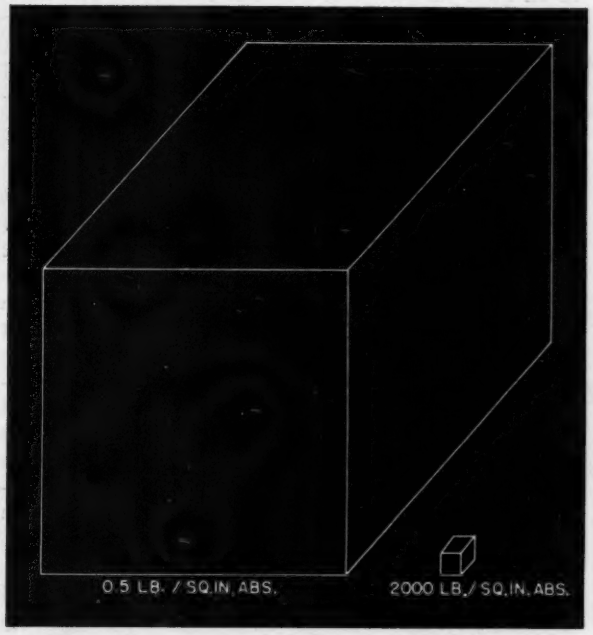


Fig. 4. Relative volumes of one pound of steam at 0.5 lb. per sq. in. Abs. and 2000 lb. per sq. in. Abs. pressure

Steam leaves the turbine exhaust still containing most of its heat, and when the vapor reverts to water in the condenser the heat is given up (heat of vaporization) is discarded. *Consequently, most of the heat put into the steam by the boiler is of no use for power.* The heat of vaporization in the exhaust steam while not usable for the generation of power may be used in any process where *heat* is required. Noncondensing turbines skim off that portion of the heat energy which is usable for power, and discharge the rest of the heat to building heating or process lines. Under such conditions, industrial processes can be charged with their share of the heat (which is great) and the turbine only charged with the heat it converts to power, or losses. Wherever a turbine can be so used power can be had at the lowest possible fuel cost.

Condensing turbines, however, must be charged with all of the heat in the steam delivered to them from the boiler.[2] Usually about two-thirds of the heat delivered is that given up when the steam changes back to water in the condenser. This heat cannot be used for power but must be discarded, thereby greatly increasing the fuel cost of a condensing turbine relative to a noncondensing turbine supplying process steam.

It becomes evident that only a part of the heat in the steam can be converted into power by even an ideal turbine. The heat converted by an ideal turbine is known as the "available energy." Turbines are not 100 per cent efficient so cannot convert all of the available energy into power, but for every set of steam conditions (main pressure, superheat or total temperature, and exhaust pressure) there is a definite theoretical amount of energy which is available for conversion into power. This available energy is the difference in the actual heat in the steam at the time it enters the turbine, and the theoretical heat remaining in the steam exhausted from a perfect turbine. (Expansion in an ideal turbine is at constant entropy.) The theoretical amount of available energy for one particular set of steam conditions is represented on the steam chart, Fig. 2, by the heavy line showing the theoretical expansion, *at a constant value of entropy,* between the initial steam condition and the final exhaust pressure. The steam conditions chosen for this line were

Main pressure, 200 lb. per sq. in. abs. }
Superheat, 100 deg. F..... } total heat 1259
Exhaust pressure, 1 in. hg. abs.....total heat 867
Energy available for power, in B.t.u., per lb.....392

A similar procedure would be followed for any other steam conditions with great variations possible in the available energy between various selected initial and final conditions.

From the steam chart it is easy to find the theoretical heat energy available for power between any initial steam condition and final exhaust pressure. The available energy obtained from the steam chart will be in B.t.u. per lb. of steam. It is the heat energy theoretically available for power in each pound of steam entering *any* turbine operating with those steam conditions, regardless of size or principle of operation. Steam admitted to a turbine at a high pressure and exhausted at a very low pressure will have much energy available for power; steam admitted at a pressure only slightly higher than the exhaust pressure will have little energy available for power. *It follows, that to generate a given unit of power fewer total pounds of steam will be required when the energy range is long than when it is short.*

The available energy in B.t.u. per lb. is used directly to obtain the "theoretical steam rate." The theoretical steam rate (abbr., T.S.R.) represents the steam required per unit of power by an ideal turbine 100 per cent efficient. It is usually expressed in pounds of steam per horsepower-hour, or pounds of steam per kilowatt-hour and, when the theoretical steam rate is divided by the efficiency of the turbine the result is the actual steam rate. To convert available energy in B.t.u. per lb. to theoretical steam rate, it is only necessary to divide the B.t.u. equivalent of a horsepower-hour, or kilowatt-hour, by the available energy. Thus we have,

$$\text{Theoretical steam rate} = \frac{2544}{\text{available energy, in B.t.u., per lb.}}$$

$$= \text{T.S.R., in lb. per hp.-hr.}$$

$$\text{Theoretical steam rate} = \frac{3413}{\text{available energy, in B.t.u., per lb.}}$$

$$= \text{T.S.R., in lb. per kw.-hr.}$$

So in the previous case where it was found that there are 392 B.t.u. available for power when steam at 200 lb. per sq. in. abs., 100 deg. F. superheat is admitted to a turbine and exhausted at 1 in. abs., the theoretical steam rate for this steam condition would be, either

$$\text{T.S.R.} = \frac{2544}{392} = 6.5 \text{ in lb. per hp.-hr., or}$$

$$\text{T.S.R.} = \frac{3413}{392} = 8.7 \text{ in lb. per kw-hr.}$$

Simple as is the determination of the theoretical steam rate, its understanding must be complete in order to quickly and easily estimate the performance of turbines designed for any steam conditions. In the following table a few theoretical steam rates have been tabulated to show the great variations possible.

Initial steam pressure, 200 lb. abs.
Initial steam superheat, 100 deg. F.

Exhaust pressure	T.S.R. in lb. per kw-hr.
1 in. hg. abs.	8.7
3 in. hg. abs.	10.1
14.7 lb. per sq. in. abs. (0 lb. per sq. in. G)	16.7
100 lb. per sq. in. abs.	54.0

These theoretical steam rates are on the basis of lb. per kw-hr., which is the usual basis for turbines driving generators. If the T.S.R. is divided by the turbine efficiency alone, the result will be the actual steam rate for outputs at the coupling of the turbine. If the T.S.R. is divided by the product of the turbine and generator efficiencies (overall efficiency of turbine

[2]This excludes those very economical condensing turbines which are occasionally used for applications where the condenser supplies hot water for process.

generator set) the result will be the steam rate in lb. per kw-hr. at the terminals of the generator.

Now note an interesting fact; *the steam rate of a turbine is far more dependent upon the steam conditions than upon the efficiency of the turbine.* For example, take two theoretical steam rates from the table, say

200 lb. per sq. in. abs., 100 deg. F. superheat, 1 in. hg. abs. T.S.R. = 8.7; and 200 lb. per sq. in. abs., 100 deg. F. superheat, 100 lb. per sq. in. abs. T.S.R. = 54.5.

Assume the first turbine with its generator has an overall efficiency of 60 per cent and the second has an overall efficiency of 70 per cent. Then in the first case the actual full-load steam rate is

$$\frac{8.7}{0.60} = 14.5 \text{ lb. per kw-hr., and in the second case is}$$

$$\frac{54.5}{0.70} = 77.8 \text{ lb. per kw-hr.}$$

Even though the second turbine is more efficient than the first, its steam rate, the amount of steam required to generate each kw. of power, is *over five* times as great! *So unless the steam conditions are identical steam rates of different turbines cannot be compared.*

Examination of the great differences in theoretical steam rates, with corresponding differences in actual steam rates, shows how much choice of steam conditions has to do with the flow of steam through different turbines. It illustrates why a turbine of the same rating as another may be required to pass a much larger flow, and may have to be built with much larger steam passages, but it does not tell the whole story of the effect steam conditions have on the physical size of turbines.

Specific Volume of Steam

The specific volume of the steam, or cubic feet of space occupied by a pound of steam, is another factor greatly influencing the physical size of turbines, and is a factor which often indicates what may be expected when a turbine is operated at other than its design steam conditions. In the accompanying table is presented a condensed tabulation of specific volume in cubic feet per pound of steam against pressure in lb. per in. abs. Note that specific volume is affected only slightly by superheat, and is almost inversely proportional to the pressure. At one-half the pressure the volume is almost doubled. So a turbine operated at one-half its design steam pressure would be expected to pass only about one-half its design flow. The power which could be developed at one-half flow would be considerably less than one-half the rating because halving the pressure would greatly shorten the available energy range. Many seemingly inconsistent relations between similar turbines are explainable when it is recalled that the space occupied by steam will increase or decrease almost inversely with the change in absolute pressure.

Graphically the relative sizes of the inlet and exhaust for turbines of the same rating but designed for different steam conditions is shown in Fig. 3. Each of these three turbines will require substantially the same flow of steam in lb. per hr. to develop its rated output. The great difference in size of steam passages is caused by the change in specific volume of the steam with change in pressure.

The steam conditions for which a turbine must be designed will have much to do with its physical size and steam rate for:

The initial pressure and superheat of the steam determine the initial specific volume which, for a given steam flow, fixes within limits the size of the steam inlet;

The exhaust pressure determines the specific volume of the exhaust steam which, for a given steam flow, fixes within limits the size of the exhaust;

The initial and final steam conditions taken together determine the quantity of energy available for power which in turn fixes within limits the number of stages required to efficiently utilize this energy, and available energy fixes within limits the steam rate of the turbine.

So it can be said that the steam conditions selected for a turbine are as important as the rating in determining the physical size and performance of a steam turbine.

NOTE: This is the third in a series of articles by the author on the subject of modern turbines. A fourth will appear in a subsequent issue.

Steam Power Favored for Nashville

Rendering its decision on erection of a coal-burning steam plant for power generation as compared with purchase of power from TVA, the Railroad and Public Utilities Commission of Tennessee has granted permission for erection of the steam plant for the following reasons, as reported by officials of Appalachian Coals, Inc.: According to overwhelming testimony of all witnesses, including E. J. Muir, engineer for TVA, the Tennessee Power Co. can generate power cheaper than it can be purchased under any rate proposed. By owning its plant, the company can make more favorable long term contracts for supplying power to consumers than it could if operating on a 5-yr. contract with TVA, with uncertainty as to probable future costs. With a steam station near the load center, disturbance of supply due to storms is less likely than with current carried over long transmission lines. Public welfare will be served by employment of labor to operate the plant, to mine and transport the coal also County and State will receive some $30,000 taxes annually. The president of the Tennessee Power Co. states that the next step will be application to the Federal Power Commission at Washington for approval, the estimated savings in cost of power generated by the 25,000-kw. plant over purchase being $127,000 a year.

Modern Turbines—Correction Note

Our attention has been directed to a typographical error in the article Modern Turbines in the October issue. On page 588, column 2, line 2 the standard ratings referred to should read between "500 and 7500 kw. instead of "500 and 750 kw." as printed.

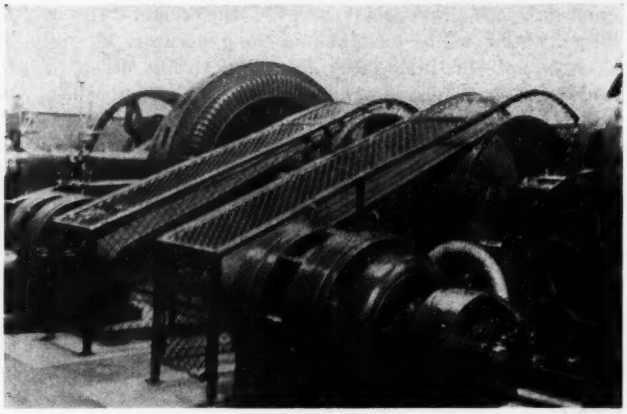


Fig. 1. New engine driven generating units at the Evangelical Deaconess Hospital in St. Louis

New Generating Units Effect Substantial Saving in Hospital Power Plant

THE INSTALLATION of two 160 hp. steam engine driven generators at the Evangelical Deaconess Home and Hospital at St. Louis, Mo., resulted in a saving of over $4000 in the first year of operation.

Until about 2 yr. ago all electric power required by this institution was purchased. There was an existing boiler installation, however, producing steam at around 100 lb. for laundry service and after a careful study of conditions, in which figures submitted by the chief engineer, Mr. Arlie Groenemann, indicated substantial possible savings by the use of generating units, plans were made to install such generating equipment. As no space was available in the existing boiler plant an engine room of sufficient size to accommodate the units decided upon was built outside of but connected to the existing service building. This resulted in the construction of a room 26 by 32 ft. connected with the boiler room through the former ash storage room.

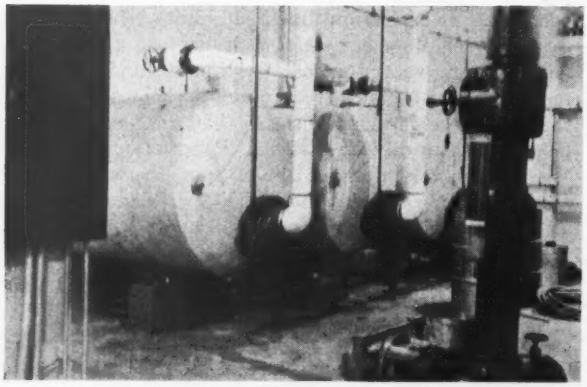


Fig. 2. Hot water heaters for laundry and general service which are heated by exhaust steam from the engines at 2 lb. pressure. Formerly three heaters used steam at 10 lb.

The accompanying drawing and photographs show how the equipment was arranged and while there was not much room for taking photographs there is ample room for operating the machinery.

The equipment consists of two 160-hp. Skinner engines driving Electric Machinery Mfg. Co. generators. One of the engines is a Unaflow while the other, a counterflow, an arrangement decided upon to make possible a better balance between the exhaust steam and electric current requirements. When a larger proportion of exhaust steam is needed, the counterflow engine is operated since its water rate is higher than that of the Unaflow. Conversely, when exhaust steam requirements are at a minimum, the Unaflow engine is used. Either unit is designed to handle the entire load with the other as a spare.

Both units are rated at 160-hp., 257 r.p.m. and operate at 130 lb. pressure at the throttle and normally against 2 lb. back pressure. As shown on the plan they are directly connected to a 156 kv-a. 240 v., 3 phase, 60 cycle Electric Machinery Mfg. Co. generator. These generators supply power for all purposes but not for lighting service. A separate single phase, 40 kv-a. 240/120 v. generator is belted to each machine for lighting service. In addition to the main generator and the lighting generator each engine also is belted to its own exciter. These are 7½-kw., 125 v. units. All belts are V-belts.

The reason for operating separate generators for lighting is largely because of a heavy elevator load which at times results in voltage disturbances which while they do not affect power equipment would seriously affect the lighting as well as X-Ray service if the lighting circuits

were fed from the main generators. Such trouble is very effectively avoided by the use of separate generators.

These generating units are really larger than are necessary at present. From the standpoint of existing requirements, two 75-kw. units would have been large enough, but in view of the fact that they add a nurses' home and electric cooking some time in the future, it was decided to make the two units 100-kw. The engines, therefore, were designed for 100-kw. normal full load service. However, a careful study by the electrical people determined the advisability of furnishing oversize generators due to the extreme fluctuations of load caused by the push button elevators with across the line starters. Accordingly, therefore, the generators selected for the power load were rated at 156 kv-a.

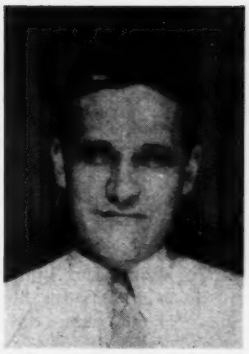
The two engines are set side by side as shown, with the switchboard facing the units in the center of the room. The switchboard is a three panel vertical board furnished by the Electric Machinery Mfg. Co. and consists of two generator panels and a lighting panel. A swinging bracket carries the synchroscope and the a.c. and d.c. voltmeters. Each generator panel carries a Simplex voltage regulator, one for the lighting circuits and the other for the power circuits.

Pay-Out-of-Savings

The engines were sold by the Skinner Engine Co. on a pay-out-of-savings basis, and during the first year, the installation effected a saving of over $4000 over that which would have been spent for purchased power. During this first year the total output of the plant was 334,781 kw-hr., which, if purchased, would have cost $7099. The running cost of the new plant was $3071, a difference of $4028 gross in favor of the engines.

The generating units are of ample capacity not only for the present load but to care for a possible future nurses' home, as well as electric cooking equipment.

Until about two years ago all electric power used was purchased. Since steam was required for other purposes, it was thought that power could be produced more economically by installing generating units, and after an analysis by Mr. Arlie Groeneman, this proved to be the case. It was on the basis of figures submitted by Mr. Groeneman that the generators were installed



Arlie Groeneman, chief engineer

Steam is supplied by two 150-hp. h.r.t. boilers operating at 140-lb. pressure, on natural draft and fired by Cokal stokers. These boilers had previously been used only for supplying steam to the institution for various purposes but since a large proportion of the steam load is for building heating and for heating service water, these services can be supplied just as well by exhaust steam from the engines. There are three large storage hot water heaters which formerly used steam at 10-lb. pressure. With the installation of the engines, however, these were supplied with exhaust steam at 2-lb. pressure.

Steam required for the laundry, kitchens and sterilizers is reduced in pressure by reducing valves to 80 lb., 35 lb. and 60 lb. respectively.

Other equipment in the plant includes zeolite water softeners for supplying both the laundry and the hospital proper, and refrigerating apparatus. The latter involves a 6 by 6 in. York automatically controlled ammonia compressor driven by a 25-hp. Century motor, together with a brine cooling system for general refrigeration service and for making ice. The plant is capable of freezing 21—100-lb. cakes at one time.

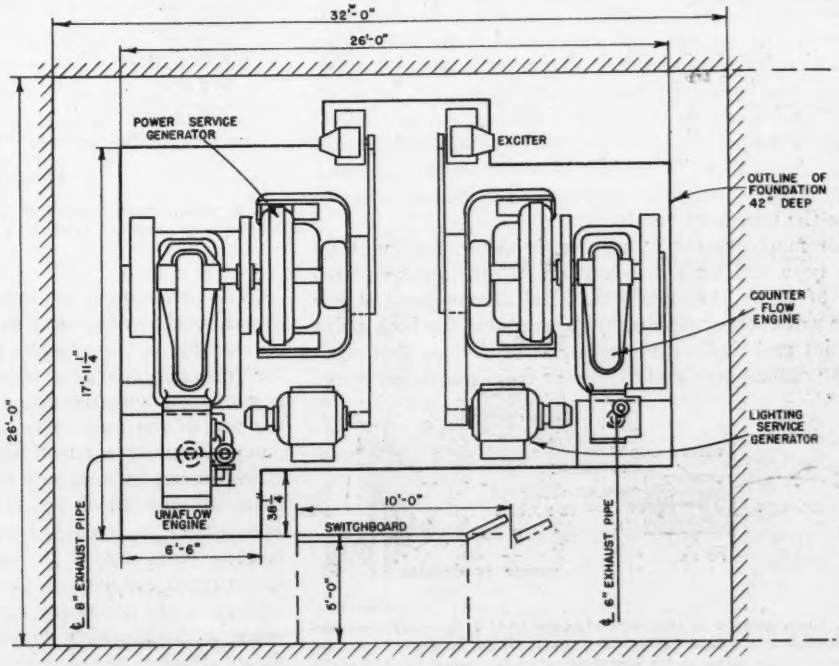


Fig. 3. Plan showing the compact arrangement of the two 160-hp. generating sets in a space 26 by 32 ft. Each engine is direct connected to a main generator and belted to both an exciter and a lighting service generator

Indicating the High Speed Diesel

Part II. For some purposes the point-by-point and sampling indicator has many advantages for high speed work. Many types have been developed and several of the most useful types are discussed below. Part III shows what different types of indicator diagrams disclose to the trained engineer

By E. T. Vincent,
Chief Engineer, Diesel Division,
Continental Motors Corp., Detroit, Mich.

DIFFICULTIES met with in the early type indicators, were fully appreciated and in order to avoid them the "point-by-point" type was introduced about the period of the Great War. As the name implies, the instrument records one or more points on the diagram each cycle. To obtain a complete card some two or three hundred cycles are necessary, so that an average of the engine performance over a small interval of time is recorded.

This average diagram is claimed by some to be far more useful than a single cycle since it shows up variations in operation which the single card does not. It is considered that the choice of instrument depends a great deal upon the purpose for which the diagram is required. In the ordinary course of engine development, the writer considers the average card given by a point by point instrument of greatest use. For example in testing a gasoline engine with incipient detonation this fact will be shown up by such an instrument even before the detonation becomes audible. Variation in spark timing, etc., can also be seen by such an instrument. If, however, the tests are directed to any particular phase of combustion phenomenon, etc., a diagram of a single cycle is necessary. Such work is usually of the research type and special complicated instruments are justified in order to secure the necessary results.

For most practical purposes, however, the point by point type will meet the demands of all high speed engines of today. Obviously an ideal arrangement is one where satisfactory equipment is available for both point by point and single cycle work. It is obvious that since the instrument only records one or more points per cycle, the whole cyclic period of the engine is available for movement of the instrument from one point to the next. Assume a four cycle engine operating at 3000 r.p.m. We then have one complete cycle every 0.04 sec. and a single cycle indicator must record in this small fraction of time the piston position, and, the pressure acting on it at every instant, this pressure changing from that of low magnitude during the exhaust and intake strokes to pressures of high magnitude coupled with rapid fluctuation during combustion. In this same time of 0.04 sec. the point by point instrument records only two contiguous pressures as close together as is desired. The complete diagram is recorded in possibly 15 instead of 0.04 sec.

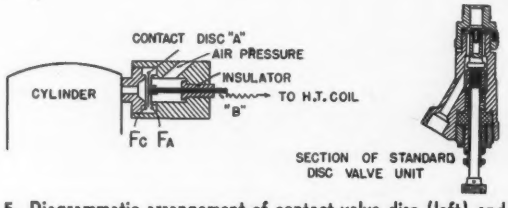


Fig. 5. Diagrammatic arrangement of contact valve disc (left) and section through a standard valve unit (right) of the Farnboro indicator. The use of these valves in the complete setup are shown by E of Fig. 6

Possibly the most popular of the point-by-point instruments is the "Farnboro" electric indicator developed by the Royal Aircraft Factory in England. The indicating method adopted for this instrument consists in recording the crank angle at which the cylinder pressure balances an applied known air pressure. There are, in general, two such balance points per cycle. One when the cylinder pressure is increasing and the other when it is falling. By gradually increasing the air pressure, a set of points is obtained covering the whole range of cylinder pressures, each pair or more of points belonging to a different cycle.

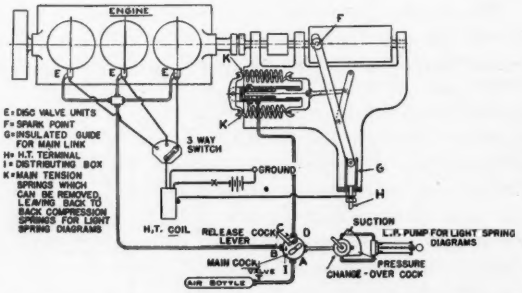


Fig. 6. Diagrammatic sketch of the indicator of Fig. 5 as used on a multi-cylinder engine. Valve Units E are shown in detail by Fig. 5

The principle of the indicating unit, is shown in Fig. 5 and consists of a light contact disc valve A subjected on one side to the cylinder pressure and on the other to the gradually changing known air pressure. The valve A is guided by a central spindle B which is insulated from the rest of the unit. This spindle is coupled to the primary circuit of a transformer. The valve A is capable of movement between two seats F_c and F_a both of which form the ground of the primary circuit. The disc has about 0.007 in. freedom between the two seats, so that in passing from one to the other the primary current is interrupted for a short period and this induces a high voltage in the secondary circuit. This voltage is used to cause a spark which burns a small hole in a sheet of paper attached to the recording drum.

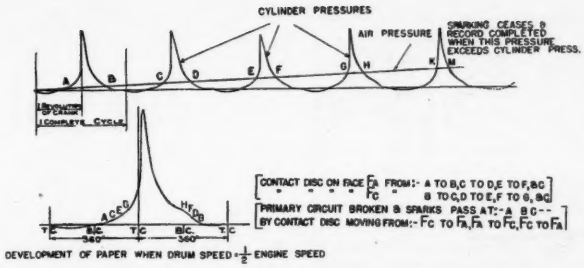


Fig. 7. Demonstrating the principle of the Farnboro point by point indicator operation and the build up of the final card from the perforated record

This recording mechanism for pressure consists of applying the same air pressure, as is applied to the balancing valve to a piston attached to calibrated springs. This piston is fitted with a magnifying mechanism which records the piston movement under the action of the air pressure. The complete set-up is shown diagrammatically in Fig. 6. Since the air pressure is changed at will by the operator, the piston movement can be as slow as desired, thus avoiding all inertia effects so that a large diagram can be secured. The diagram is recorded on a time base by means of a drum of large diameter driven direct off the engine. This combination results in a diagram some 13 in. long by 6 in. high, and errors in measuring, etc., are small.

Assume 100 lb. per sq. in. air pressure applied to the valve A, Fig. 5. This pressure also communicates with the recording piston and under the control of the springs the tracing point moves over the paper on the drum a distance proportional to 100 lb. per sq. in. This distance depends on the attached spring as in the ordinary piston indicator. The valve A is held on to its lower seat F_c by this air pressure and as the engine cycle proceeds the pressure underneath the valve increases during the compression stroke until 100 lb. per sq. in. is reached.

Then the valve is in equilibrium but as soon as this pressure is exceeded, the valve is blown to the opposite seat F_a by the excess cylinder pressure. In doing so the primary circuit is interrupted and a spark from the secondary circuit passes from the point of the pressure recording mechanism through the diagram paper to ground. The diagram paper is directly coupled to the engine and driven at either crankshaft or half crankshaft speed, in known phase with the engine. The small hole burned by the spark in the paper is plotted proportional to pressure and crank angle, giving a diagram plotted on a time or angle base. In Fig. 7 is shown the build up of a diagram over a number of cycles. Of course in the actual instrument, the cycles are wrapped around, one on top of the other on the one sheet of paper, and the complete diagram appears as shown in the bottom left hand corner.

Sampling Valve Indicator

This instrument is also a point-by-point instrument but operates on a slightly different principle. Instead of balancing the cylinder pressure with another equal to it, an actual sample of the cylinder gases is tapped off from the cylinder at a particular phase of the cycle and its

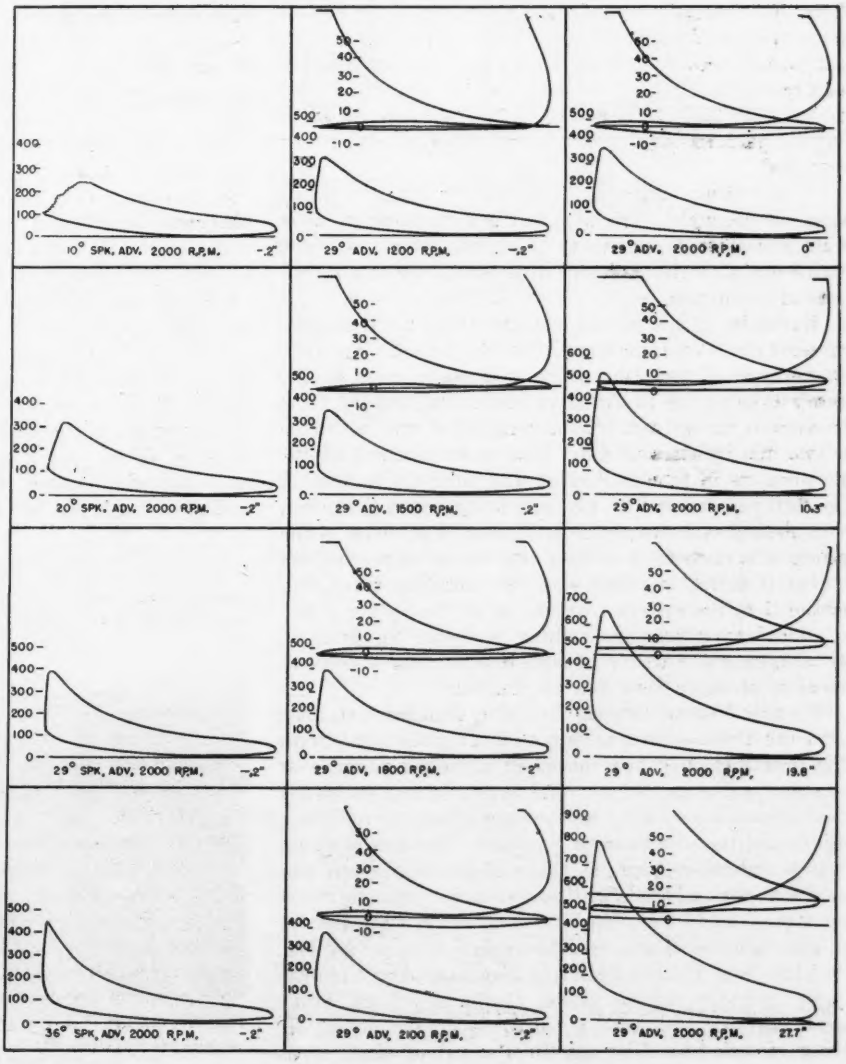


Fig. 8. Cards from a Prescott indicator. The left hand column shows the effect of variable spark advance, the middle column shows the effect of variable speed and the right hand column shows the effect of varying the supercharge pressure. In each case other conditions were held constant

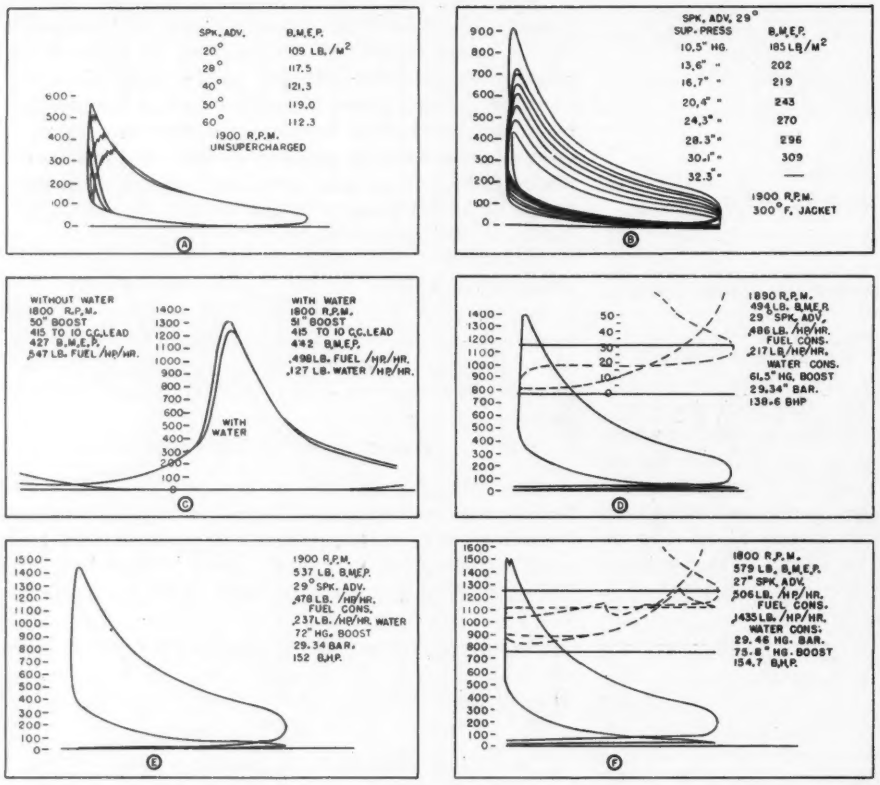


Fig. 9. Cards from the engine and indicator shown by Fig. 10. A b.m.e.p. of 579 lb. per sq. in. was reached in Diagram F. Diagram B shows the effect of supercharge pressure on the shape of the card and C the effect of water injection

pressure measured. The phase of the sampling point is gradually shifted relative to the crank over the whole engine cycle, to give a record of the pressure at all positions of the piston.

Examples of this type of instrument are the De Juhas, Prescott and Cox indicators. The first two differ chiefly in the type of sampling valve employed, being of the rotary type in the first and poppet in the second. The pressure is tapped off from the cylinder over a degree or two of crank travel only, and, assuming no leakage, the pressure in the instrument will build up to that in the engine cylinder. This pressure is applied to the piston of an ordinary indicator for recording. The drum of the indicator is connected to the phase changing mechanism so that it moves in phase with the sampling valve proportional to the cylinder volume at any sampling point, so an ordinary pressure volume card can be obtained. By changing the drum phasing mechanism, a conventional combustion card can be secured.

Figure 8 shows typical indicator diagrams secured from the Prescott instrument under various conditions. The first column shows the effect of spark advance at constant engine conditions. The second column shows the effect of variable speed with constant spark advance with other conditions remaining constant. The final column records indicator diagrams taken at constant speed and constant spark advance with supercharge pressures varying from 0 to 27.7 in. Hg. A set-up of the indicator on an experimental single cylinder engine is shown by Fig. 10, while Fig. 9 shows indicator diagram taken from the single cylinder engine under abnormally high brake mean effective pressures, a value of 575 lb. per sq. in. being recorded on Diagram F. Several of these cards also show the effect of water injection with supercharger and Diagram B shows superimposed the change in shape of indicator cards with varying supercharging pressure.

In the Cox Indicator, the sampling valve is electrically operated, a solenoid being energized to lift the needle type valve from its seat for a small fraction of time and permit the pressure to be sampled at any crank angle. By means of electrical contacts, the phase of the point of valve opening is changed. This instrument is worked out in great detail and is set-up so that all cylinders of a multi-cylinder engine can be indicated simultaneously and the records are visible as they are drawn.

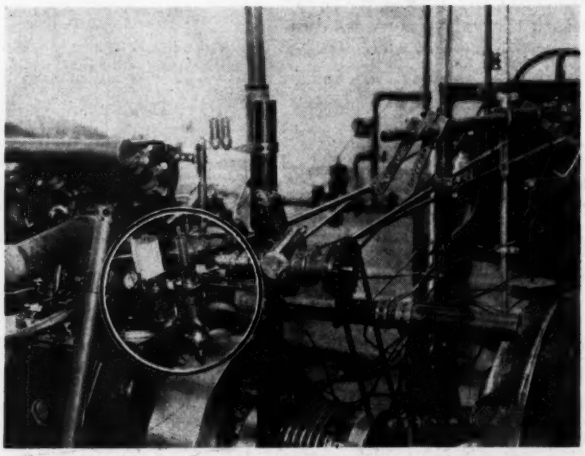


Fig. 10. Set up of a Prescott sampling valve indicator on a single cylinder experimental engine. The indicator is shown within the white circles. Cards from this engine are shown by Fig. 9

Despite the fact that twenty articles on the subject of Electron Tubes have been presented in this series so far, little has been said about the simplest types of electron tubes—the cold cathode tubes. Although their use is limited, the theory of their operation is interesting and the discussion of these tubes as presented here is desirable towards a better understanding of electronic phenomena as a whole.

ELECTRON TUBES— Principles and Applications

Part XXI

By A. W. KRAMER

IN ALL THE DISCUSSION of electron tubes and electronics presented in this series of articles thus far, little has been said about the simplest type of tubes —those known generally as the cold cathode tubes. Brief reference to them was made early in the series[1] as a matter of historical interest but nothing was said about their modern development or their applications. No treatise on electron tubes would be complete, however, without some consideration of the cold cathode tubes, not only because they were the first vacuum tubes but because even today, though their use is limited, in certain forms they find practical application—application where currents of low intensity are involved.

As was related in an earlier chapter, years ago it was discovered that when two terminals were sealed into the ends of a glass tube and the tube exhausted of air, an electric current could be made to pass across the empty space inside by the application of sufficient electric potential to the terminals. The voltage required was high but the fact that a current of even the smallest magnitude could pass was astonishing and at first quite unexplainable. At that time there was no electron theory to account for the passage of electricity across empty space. Of course the space was not empty, there was rarified air inside, but this did not particularly clarify the situation.

These were the first "vacuum" tubes—not really vacuum tubes because there was gas inside, but they were called that. If the potential applied to these tubes was high enough, a luminous discharge would fill the tube, often producing beautiful and weird effects. In view of present day knowledge the nature of this luminous discharge is no mystery, not to the scientist at least, and we see a more practical application of the principle in a hundred million brilliant and colorful luminous tube signs throughout the so-called civilized world. Today we know that the luminosity is due to the effect of intense ionization of the gas molecules and atoms inside the tube—to the recombination of positive and negative ions and to excited atoms returning to normal states[2]; but at the time these discharges were first

[1]Part II, March 1936, page 167.

Fig. 1. Diagram of a typical discharge in a Crookes tube, showing a striated positive column.

[2]By an excited atom is meant an atom which has had one or more of its external electrons displaced into orbits of higher energy level. Such a state can exist for only a very brief instant since under such conditions the atomic system is unstable and tends to return to normal. In returning to normal, the extra energy which was required to bring the atom to its excited state is given up as electromagnetic radiation, in this particular case is visible light.

In the electron tube, the energy necessary to bring an atom into an excited state is of course derived from the kinetic energy of the high speed electrons traveling toward the anode. When such an electron collides with a normal atom one of two things can happen; if the impact is sufficiently great, some of the external electrons may be removed and the atom ionized, or, if the impact is insufficient to cause ionization, it may merely cause the displacement of one or more of the external electrons from one orbit into others, resulting in what is known as an excited state. In reverting to normal from this excited state, the atom radiates energy in the form of light.

observed, the phenomenon was quite strange and mysterious. And why not? Here, for the first time, electricity was being observed apart from matter and there was no knowledge existing at that time to account for it. Sir Wm. Crookes, after whom these first tubes were

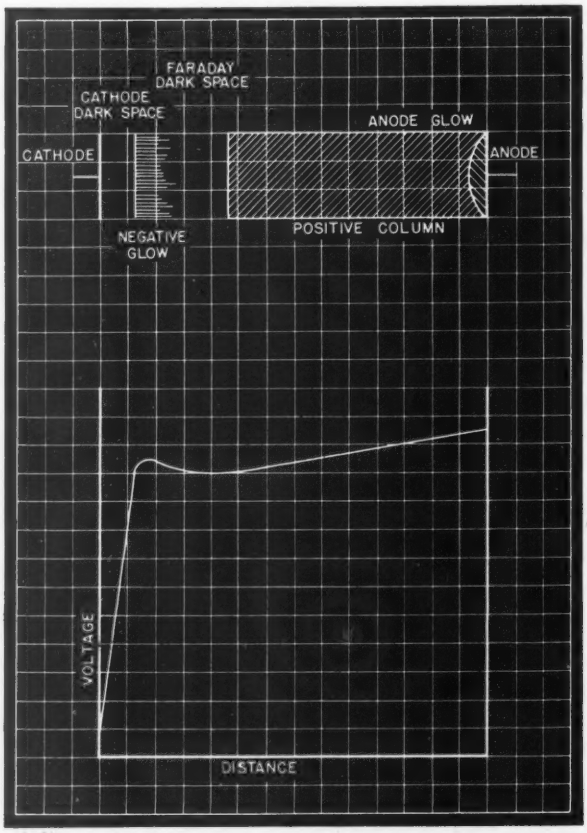


Fig. 2. The relation between the voltage distribution and the various luminous and dark portions of the discharge in a cold cathode tube.

named, referred to the phenomenon as the "fourth state of matter."

Of course, when we say that we know all about the phenomenon, today we mean that the scientists and to some extent those interested in engineering and physics know about it. Ask the average ten people you meet on the street how a neon sign works, why it gives light, and ten of them will not have the remotest idea of what you are talking about. But ask them as to the possibility of the Cubs or the Giants of winning the World's series or of the effect of packing the Supreme Court or the price of tomatoes and they will disclaim on these topics with great conviction. The average person today knows quite as little of electron tubes as the average person did before these devices existed which is a rather sad commentary on our systems and theories of education as well as the native curiosity of human beings.

In view of our knowledge of thermionics, the action of the cold cathode tube is interesting because in considering their operation the first question that arises is in regard to the origin of the primary electrons which bring about the ionization of the gas. In the thermionic tube, the electrons are emitted as a consequence of the thermal agitation of the molecular structure of the cathode but in the cold cathode tube there is no such thermal effect, both electrodes are cold. As might be expected, since both electrodes are identical, the current flows in either direction depending upon the polarity of the terminals.

A clue to the action is provided by a study of the luminous discharge when direct potential is applied to the tube. Under such conditions, the luminosity of the discharge throughout the length of the tube is not uniform. Close to the cathode there is a dark space, quite narrow but distinct and known as the Crookes dark space. Next, in the direction of the anode is a short luminous section followed by another dark space called the Faraday dark space and finally another luminous portion known as the positive column which extends across to the anode. The positive column occupies the major portion of the tube length. The relative lengths of these various dark and light portions vary according to the degree of exhaustion of the tube. At certain gas pressures, the positive column is broken up by dark bands or striations.

A study of the voltage drop across the tube with respect to the various light and dark portions of the discharge as in Fig. 2, it is noted that nearly all of an explanation of the mechanism of electron emission from cold cathodes. If the voltage distribution along the length of the tube is plotted underneath a diagram or section showing the light and dark portions of the discharge as in Fig. 1, it is noted that nearly all of the voltage drop across the tube is concentrated across the first narrow Crookes or cathode dark space adjacent to the cathode.

Since the voltage gradient at this point is very high it might be thought that electrons could be pulled out of the surface of the cathode by the sheer force of the electrostatic attraction but a simple calculation of the forces involved shows that this could not be the case. Another explanation must be resorted to if we are to explain the emission of electrons from a cold cathode.

As a matter of fact the explanation is not simple—not nearly so simple as that of thermionic emission. To account for a discharge of electricity through such a tube, it is necessary to assume that there is a certain amount of ionization in the gas before the application of voltage. Without the assumption of such initial ionization there is no way of accounting for the initiation of the discharge.

Fortunately it is relatively simple to account for such initial ionization; indeed it would be much more difficult to show an absence of ionization, especially since the recent disclosures of the effect of cosmic rays. Due to the ionizing influence of cosmic radiation from outer space or to emanations from radioactive material in the earth's crust, there is always a small amount of ionization in any gas, no matter how effectively we try to isolate the gas. The gamma rays of radium are capable of penetrating several inches of lead, and cosmic ray researches have shown radiation of this form to be capable of passing through six feet of solid lead. Since such rays—x-rays, gamma rays and cosmic rays, are capable of ionizing atoms it is evident that unless the most elaborate precautions were taken, it would be extremely difficult to provide a tube of rarified gas in which there were no ions. There will always be a few ions in any quantity of gas however minute.

Assuming a certain number of positive and negative

ions to be present in any gas let us see what happens in a tube of rarified air when voltage is applied to the terminals. Under the action of the electrostatic field, the positive ions will be driven toward the cathode while the negative ions, that is the electrons, will move toward the anode. The positive ions being much more massive than the electrons will accelerate less rapidly than the electrons but by virtue of their enormously greater mass their kinetic energy is correspondingly greater. The consequence of this high kinetic energy of the positive ions is that they bombard the cathode surface with such force as to knock electrons out of the surface of the metal. These electrons upon leaving the surface of the metal find themselves, so to speak, in a region of high positive space charge due to the presence of large numbers of positive ions near the cathode and by virtue of this charge are accelerated in the direction of the anode. The high concentration of positive ions close to the cathode is responsible for the high potential gradient in the cathode dark space.

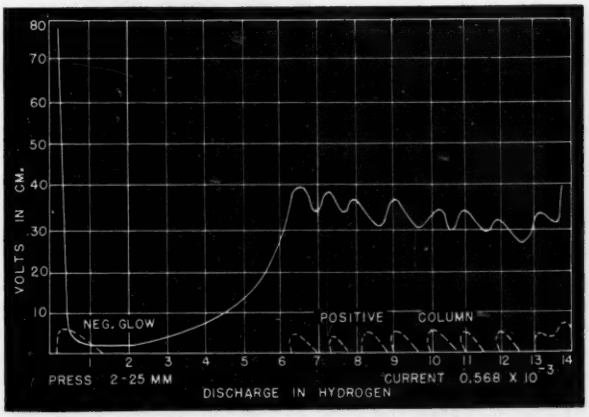


Fig. 3. The voltage distribution in a cold cathode tube when the postive column is striated.

There will thus be a stream of electrons through the dark space, some of which have started from the cathode and acquired energy from the high potential gradient adjacent to the cathode and others which have originated in the dark space itself which do not have so much energy. These electrons constitute a stream of energy passing out into the adjacent region, a stream of energy sufficient to ionize a large number of molecules without any help from the outside. The local field (created by the potential applied to the tube) does not need to supply energy to ionize the gas but merely to give a drift to ions made without its assistance. For this, a very weak field will suffice and, in the negative glow, which is the result of the ionization, the field is so small that there is often not a difference of potential of even 1 volt from one end to the other.

In effecting ionization in the negative glow the electrons lose energy continually and since the potential gradient in this region is very low they slow up to such an extent that they are no longer able to ionize the gas. This results in the next dark space—the Faraday dark space.

There is, however, sufficient residual field in this region to again accelerate the electrons toward the anode, not so rapidly as in the cathode dark space but still enough so that after traveling a short distance they again attain sufficient energy to ionize the gas. Thus, the luminous positive column is accounted for.

As ionization begins again, a concentration of ions again occurs resulting in the establishment of another space charge. This causes the potential gradient to rise, often to a point considerably above the ionization potential. What happens from here on depends upon the condition of gas pressure, voltage, and design of the tube. If the energy of the electrons is high enough they will be able to ionize gas with little or no further assistance from the local field and there will be a region analogous to the negative glow where the electric force is very small. The energy of the electrons will be exhausted after passing through a certain distance toward the anode and again there will be a region corresponding to the Faraday dark space in which the electric field increases until another negative glow forms, thus, the cycle begins again. Under these conditions the discharge will consist of a regular alternation of light and dark regions such as exhibited in the striated positive column. A condition of this kind is depicted in Fig. 1.

Under certain conditions of gas pressure and potential, a different action is possible. If, instead of producing a large concentration of ions in certain regions giving rise to a variable voltage gradient, the degree of ionization is such as to result in just enough new ions to supply the loss of old ones due to recombination, attachment to molecules or diffusion to the sides of the tube, a steady discharge is possible and the result will be a uniform positive column. This is the type shown in Fig. 2.

The conditions under which one or the other type of discharge occurs are complex and they need not be considered in detail, since the phenomena is referred to here only as a matter of passing interest, but they are subject to logical explanation in the manner described briefly here.

The thing we are concerned with here is not so much the mechanism involved in producing the luminous and dark regions of the discharge, but in the way electrons are emitted from the surface of the cold cathode. This, as we have pointed out, is undoubtedly due to the bombardment of the cathode by the positive ions. That there is such a bombardment can be shown by experiments with a perforated cathode. With such a perforated cathode, positive ions can be detected streaming through the holes at the back of the cathode.

So much for the "Crookes" tube. In its original form as described here, it has no practical application but it was the forerunner of all the different tubes existing today and the principles underlying its operation are those which govern the action of all cold-cathode tubes today.

As was pointed out, such a tube having simply two

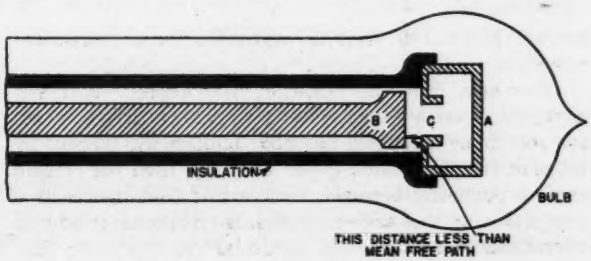


Fig. 4. The elements of a cold cathode rectifier tube.

plain electrodes conducts current in either direction. By properly designing the electrodes, however, shaping them and spacing them, it is possible to give the tube unilateral conducting properties. Such a tube is shown in Fig. 4. As shown, this tube has two dissimilar electrodes, one, A, in the form of a hollow cylinder having a hole C opposite the middle of the other electrode, B, which is a flat disc. The distance between the disc and the end of the cylinder is less than the mean free path of the electron, therefore, an electron moving across this space only cannot bring about ionization because it collides with no gas molecules. An electron starting from the middle of B, however, may shoot right into the hollow cylinder, A, and in the distance available such an electron will produce ionization. In traveling from B to the outer edge of the hole C, it must, however, gain sufficient velocity to produce ionization since it gains no more velocity after it enters the hollow cylinder. All parts of the cylinder, naturally, are at the same potential, hence, there is no potential gradient to accelerate an electron inside the electrode A. This is the reason no electrons leave the inside of A to go to B.

With these characteristics, it is evident that when an alternating potential is applied to the tube it will conduct current when A is positive but not when it is negative and B is positive. This tube, therefore, is a rectifier.

The rectifying action, however, is not perfect because of the varying nature of the electronic collision. Suppose the mean free path of the electron to be 1 millimeter, that is to say, the average electron travels 1 millimeter before colliding with an atom. There will, however, be some electrons which collide with atoms after traveling only ½ millimeter or even much less, and, of course, these will produce some ionization; even in the inverse direction, therefore, such tubes carry some current.

The voltage-current characteristics of a cold cathode rectifier tube of this kind are shown in Fig. 5. It begins to conduct current at around 130 v. and as the voltage is increased the current rises rapidly. In the reverse direction, however, the current begins to flow at 180 v. and increases gradually but uniformly as the voltage is raised. As can be seen, the current in this direction is by no means as large as in the *permeable* direction,

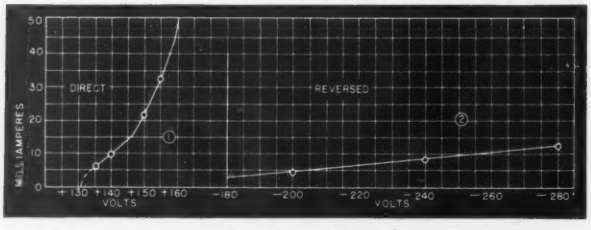


Fig. 5. The current voltage characteristics of a cold-cathode rectifier.

in fact below 180 v. it is negligible for all practical purposes.

For any purpose, however, the current carrying capacity of such tubes is relatively low and their use for rectifying purposes has been superseded largely by tubes of the thermionic type. They are used for certain control purposes, however, and in this field their action is similar to the action of the hot cathode triode or thyratron.

The principles involved in the use of cold cathode tubes for control purposes are easily understood from Fig. 6. In this diagram the two sides of the circuit are identical and interchangeable. With all the resistance in on each side of the circuit an extremely weak current flows in each side but no major discharge can take place because of the high resistance. If either of the resistances is made small enough so that a major discharge can take place, then the positive electrode in series with that resistance will be the anode and the other electrode will be the grid. Instead of having two identical variable resistors as shown in Fig. 6, the ballast resistance may be of a coil of a relay as shown in Fig. 7. The resistance of such a relay may be of the order of 500 ohms but the grid resistance will be much higher.

For the purpose of explaining the action, let it be assumed that the tube is designed to discharge when the voltage across the cathode to anode is 200 v. Suppose

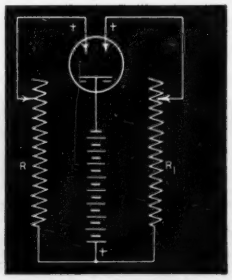


Fig. 6. Showing the principle of grid control in the cold-cathode tube.

the anode voltage to be adjusted to a value of 199.8 v. without the grid connected. If the grid resistance is of such value that it will permit enough current to flow to increase the voltage by 0.2 v. the total voltage across the tube will be increased to 200 v. and the tube will discharge. In other words, the only function of the grid is to add that small increment of voltage which is needed to cause the tube to "break down" when the voltage is adjusted to a point just below break-down value.

In the practical application of these tubes, the control resistor may be a device of the electronic type, a phototube for example. With such an arrangement, light falling upon the cathode of the phototube changes its normally high resistance to a lower value causing the cold cathode tube to discharge and actuate an electromagnetic relay. In this way a relatively large amount of power can be held in check until released by the action of a light ray.

Another way of operating these tubes is to provide the grid with a negative bias by means of a bias battery as shown in Fig. 8. In this case the discharge can occur only when the negative bias is decreased.

After the grid potential has been suitably altered to permit the tube to break down and conduct current, the grid is powerless to control the anode current further; it may be made highly negative but unless this negative potential is made extraordinarily large no effect is produced on the anode current. The grid can start the current but it cannot stop it. The only way to stop the anode current is to reduce the anode potential to such an extent that the arc discharge cannot be sustained and the discharge "goes out." If the anode voltage remains off for only a few microseconds, the state of ionization in the gas disappears and the grid again regains control. The anode current will not start again

unless the grid bias voltage is again lowered sufficiently to allow the arc to restrike.

From this description it is quite evident that these tubes act very much as do the hot cathode grid controlled gas filled tubes. The only real difference is in the current carrying capacity; the cold cathode tubes are capable of carrying only comparatively small currents. In these tubes there is no proportionality between the anode current and anode voltage; the tube either conducts to the limit of its ability or it conducts not at all. The tube is, therefore, a relay, with characteristics similar to an electromagnetic relay.

These cold cathode grid-glow tubes belong to what is known generally as the "trigger" relay class. They are used to control relatively large amounts of power from extremely small actuating forces. The output of the grid glow tube can of course be delivered to the grid circuit of thermionic amplifiers so that any amount of power can be controlled by an almost infinitesimally small actuating impulse. One of the first "stunt" applications of this principle was used when the late Judge

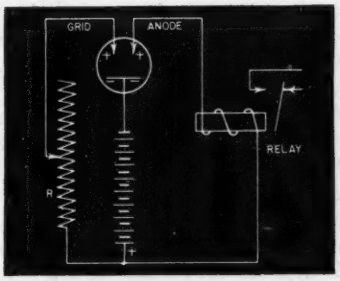


Fig. 7. The ballast resistance of Fig. 6 may be that of a relay coil as shown here.

Gary sitting in his office in New York started a new rolling mill in Pennsylvania by waving his hand over a metal ball on his desk. The capacity effect of his hand on the ball was sufficient to alter the charge on the grid of a grid glow tube and, thus, it initiated an impulse which passed through a series of amplifiers and relays and finally closed the starting contactors of the electric motors driving the mill.

Another application of the cold cathode type of tube is to limit the voltage of a circuit below a certain maximum value—to keep dangerous high voltage surges from causing injury to electrical apparatus connected to the line. Such a tube, like any other of the cold-cathode gaseous tubes takes a reasonable high voltage to break down, and when broken down it carries high currents at reasonably low voltages.

The UX 874, manufactured by R.C.A. and used in many of the earlier radio sets is a tube of this kind. In this tube cylindrical electrode serves as the cathode and an axially placed stiff wire as the anode. The breakdown voltage of this tube is 125 v. when the wire electrode is positive and the voltage then drops to its safe operating value of 90 v. Larger tubes of this kind but having symmetrical electrodes are used for operation on a.c. lines. The continuous current rating of such a tube may be only a quarter of an ampere but for a period of one second it will carry as much as 200 amperes. Thus with such a tube connected in the circuit, a high energy surge appearing on the line will discharge through the tube without damaging apparatus connected to the line.

It seems almost unnecessary in this discussion to mention the gaseous tube lamp characterized by the neon sign lamp, so conspicuous a part of our city night life, yet the neon lamp, as implied earlier in this article, is a true electron tube and deserves mention. The light is due to ionization of the gas by the current through the tube. The color of the light is entirely a function of the composition of the gas; it is related to

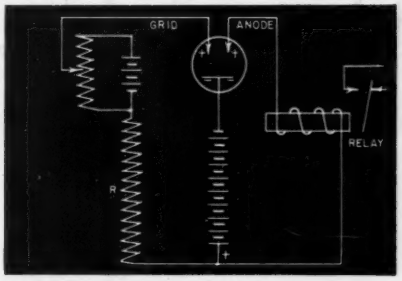


Fig. 8. Showing the use of a negative bias on the control grid.

the energies with which the electrons of various gas atoms are held in their orbits.

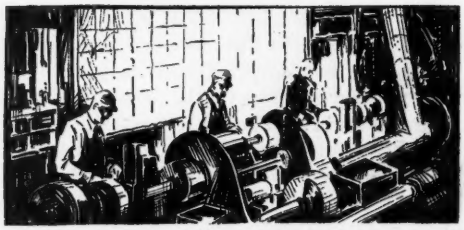
Aside from their value as sources of illumination, neon (or other gaseous discharge lamps) are useful in electric circuits when associated with condensers and resistors, as oscillators. When used for this purpose current is allowed to flow slowly, if desired, into a condenser through a series resistor. Across this condenser is a glow tube designed to break down at some predetermined voltage. When the voltage across the condenser reaches this critical value the glow tube breaks down and the condenser discharges through the tube. Then the condenser begins to charge again and the cycle is repeated. By properly choosing the values of resistance and capacity, the frequency of oscillation may be controlled over a considerable range.

Condenser Tube Life As Affected by Corrosion and Wear

SEVERAL TYPES of wear have been experienced at times with the cooling tubes of surface condensers, but often it is extremely difficult to clearly separate corrosion and wear effects, said N. L. Mochel of Westinghouse, before the A. S. T. M.

Exhaust from large single cylinder turbines, carrying large quantities of water under high velocity, has been known to cause very marked wear of the tubes in the upper rows. In some cases, steel grids and baffles have been installed to protect the tubes, and the author has observed cases where the action was so severe on these steel parts that one would almost believe that the metal had been subjected to a sandblast. The removal of moisture from the turbine by the moisture catchers, referred to above under low-pressure blading, has materially assisted in this problem. A better distribution of the incoming steam to be condensed has also been effected in the design.

In some small condensers serving auxiliaries, where steam velocities have been quite high, some wear by "steam cutting" has been noted. Impingement attack on the inside of tubes, due to the impingement of the walls by air bubbles in the circulating water, has resulted in rapid tube failure in a goodly number of cases.



Use of Growler In Plant Maintenance

BY J. M. MEYERS

TESTING TRANSFORMERS, or "growlers" as they are usually called, are made in many sizes and shapes. They are used for a great many purposes, chief among which are: testing of motor armature- and field-coils, for short-circuits and grounds, demagnetizing tools and other articles that have become accidently magnetized, recharging permanent magnets, that have lost their magnetism or become weakened, etc. They have also been used successfully by doctors for removing loose or slightly imbedded pieces of iron or steel, and metallic dust from patients' eyes.

The growler described in the following paragraphs may be considered as a core-type transformer having a primary coil with one side of the iron core missing. This coil is excited with alternating current of the proper voltage and frequency for which it is wound.

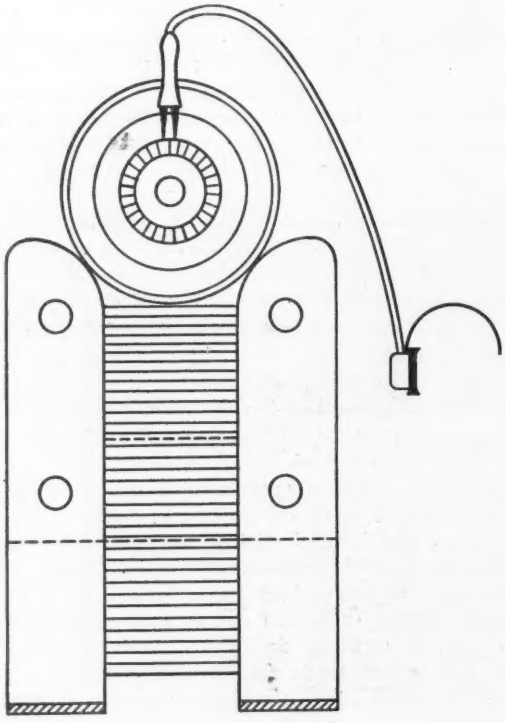
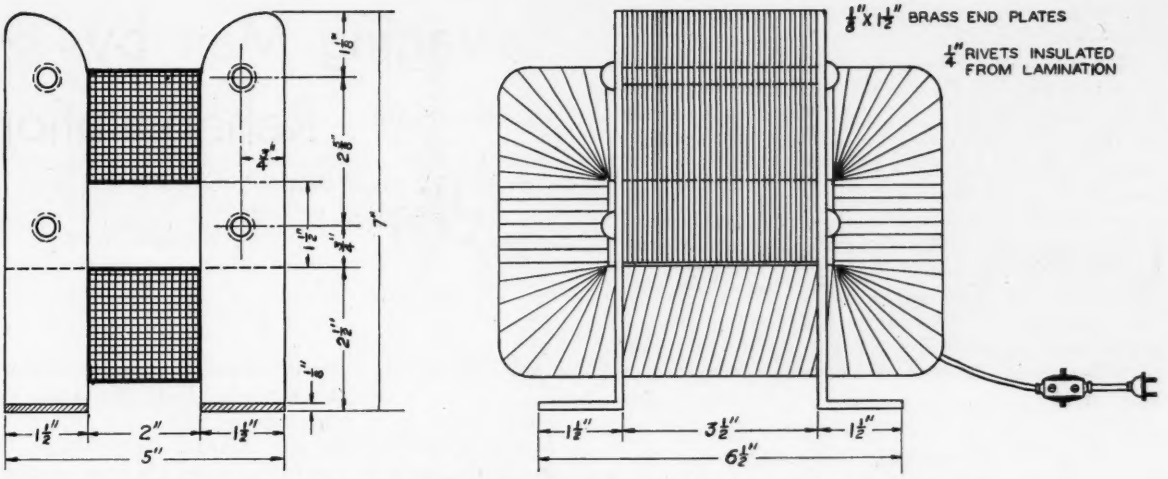


Fig. 1. Testing armatures by means of growler

When a short-circuited coil is moved into the field of the testing magnet, a reaction is set up in the coil similar to that of a short-circuited transformer secondary coil. The primary being the exciting coil on the growler. The magnetic circuit is composed partly by the core of the machine under test, and partly by that of the testing transformer. As in any short-circuited transformer an increased current flows in both the primary and secondary coils. This is due to the tendency of the defective coil to de-magnetize the core of the growler. This increase in current can be detected in several ways; by an ammeter connected in the circuit of the testing transformer, by the local heating that takes place in the defective coil, or by the attraction that the short-circuited coil has for a thin strip of iron, such as a hack saw blade, when held over the slot in which the opposite side of the coil undergoing the test is located.

Field coils of alternating current motors are tested for shorts between turns in individual coils, or between the top and bottom halves of coils lying in the same slot. In stators that are being rewound, the coils are tested after the wedges are in place but before they are connected. For assembled motors the rotors must be removed, although it is not necessary to disconnect the coils for testing with the growler. The growler of course must be of suitable capacity for the motor under test. It is placed in the bore of the stator with the testing poles over the laminations of the motor and the growler coil parallel with the motor coils, thus the iron in the motor forms a return magnetic circuit for the flux from the growler. The current is turned on the coil of the testing magnet and it is moved slowly around the inside of the stator. If an ammeter is connected in the growler circuit an increased reading will be obtained when a short circuited coil is passed. If an ammeter is not available, a hack saw blade is passed lightly across the laminations containing the opposite sides of the coils under test. A shorted coil will give a strong attraction to the feeler and a distinctive hum or chatter will be noticed. The defective coil will also heat very quickly if the growler is of the proper size.

The winding under test may also be tested for grounds by touching one side of the coil or winding to the frame of the motor. If a spark is noticed, the coil



Figs. 2 & 3. Details of small growler for general purpose testing built of 0.074 in. L-type laminations

is grounded, otherwise it may be assumed to be free from grounds.

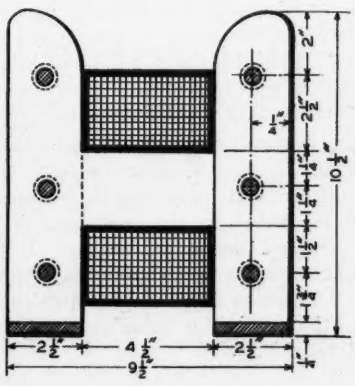
Direct current armatures are easily tested for open coils, grounds and short circuits by means of the growler. In testing armatures of this type the testing transformer is placed on a suitable workbench and the armature placed between its poles as shown in Fig. 1. For locating the above faults the testing magnet is energized from a suitable a.c. source and the armature revolved one step at a time until all the coils have been tested. A suitable ammeter in the growler circuit will help detect the faults, but the usual procedure is to connect a telephone receiver or ear phones to a testing fork, which has prongs, or points, so spaced as to span one mica segment. If ears phones are not available a suitable test lamp may be used instead. The test fork is kept near the top of the commutator, as the armature is rotated, and any change in tone in the receiver or brilliancy of the test lamp, indicates a defective coil. An open circuit coil gives no indication when under test and is, therefore, assumed to be open. When rewinding an armature it is best to make a feeler test of the coils before connecting them to the commutator, and also to test them for grounds. The commutator segments are also tested before the coils are connected. If a short circuit is indicated in an armature that has the coils connected, the segments which indicate the defective coil are bridged with a piece of metal. If a spark is noticed when the contact is broken, the short circuit is in the coil, if no spark is made then the commutator bars are shorted. The armature of single phase a.c. motors having commutators may also be tested in this manner.

Growler Used for Demagnetizing

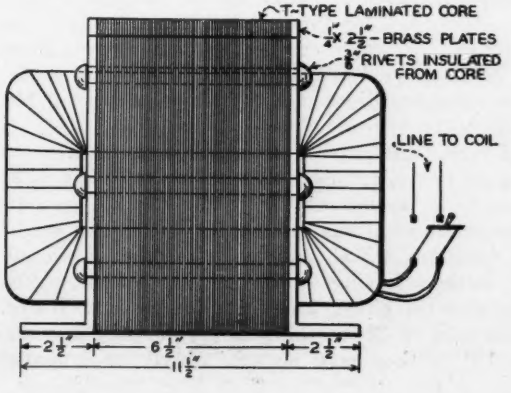
Quite often watches, tools, or machine parts become accidentally magnetized, causing much trouble. This may be easily remedied by placing the magnetized parts in an alternating current magnetic field, such as is produced by a growler. When the current is on, the parts are slowly moved out of the magnetic field. It is sometimes necessary to do this several times to completely demagnetize the articles. Turning the current off before the parts are pulled away has a tendency to increase their magnetism.

Recharging Permanent Magnets by Means of a Growler

A simple means of recharging magneto and other types of permanent magnets is available in the use of a growler. Here direct current is used to excite the growler coil. Care must be taken to use a rheostat or suitable resistance in series with the coil unless it was specifically designed for direct current at that voltage. This is necessary to limit the current, as unlike alternating current there is no inductive effect to choke the current back. The magnets to be recharged are moved back and forth across the face of the growler poles, parallel with them. This is continued until the desired strength is obtained, comparison be-



Figs. 4 & 5. Large growler made from T-type laminations



ing made with the pull of a similar new magnet of the desired strength.

In one shop where a considerable amount of this work is done, a special magnet was made from wrought iron blocks, machined to the proper size and used for the face of the electro-magnet poles. These blocks were electric-welded to round wrought iron rods which formed the cores, the other ends of which were turned down and fitted into a cast iron base plate to which they were riveted after the coils had been wound on and properly insulated. A suitable number of turns was wound on the winding for the proper direct current voltage, and the magnet was fastened under the work bench so that the face of the poles was flush with the top of the bench. This magnet consumed 5.5 amp. at 110 v. d.c.

Building a Growler

In the average shop two sizes of growlers are necessary, one for testing small armatures and one for medium and large sizes. This is necessary because when testing armatures of a small size, if a growler containing a few turns of large sized wire is used, the current induced in the armature under test is likely to be heavy enough to burn the winding open before the fault can be located.

The two most common types of growlers are made from L and T-shaped laminations which may be salvaged from burned out current or potential transformers, or may be cut from suitable steel and milled into shape. If this is done, care must be taken to remove all burrs from individual laminations after cutting, drilling and milling. Insulating varnish should be placed between laminations to prevent excessive heating and iron losses.

The coil is wound on a suitable core, preferably of bakelite or fiber. When finished it is thoroughly taped and painted with bakelite or a good insulating varnish, and baked. It is desirable to paint and bake each layer when applied, but is not absolutely necessary. After the coil is finished the laminations are stacked in it, and riveted or bolted together, care being taken to see that the bolts are wrapped with at least one layer of insulating paper to insulate them from the laminations. A snap or push switch is connected in the coil leads near the growler for convenience, as it is not desirable to leave the current on when not in use.

A small growler made from L-shaped laminations is shown in Figs. 1, 2, and 3. It is suitable for armatures from two to six inches in diameter. The coil is wound with square double cotton covered wire; for 110 v. 60 cycles, 165 turns of No. 10 wire may be used. Or it may be wound with 170 turns of No. 15 wire for 220 v. and 60 cycles. If this winding is made up in two equal sections it may be used either on 110 v. or 220 v. 60 cycles.

A larger size growler suitable for testing armatures from six to twelve inches in diameter is shown in Figs. 4 and 5. It is built similar to the smaller one except T-shaped laminations are used. The coil is made of No. 6 square D.C.C. magnet wire, and is wound in two sections having 70 turns each, which makes it adaptable for either 220 v. or 110 v. and 60 cycles. When used on 220 v. the coils are connected in series. For 110 v. they may be used singly or in parallel.

Salvaging Men by Rehabilitation

Christmas Seals!

Buy and Use Them

By Roslyn Herz

AFTER a long siege of illness such as tuberculosis, getting a man back on his feet, physically and industrially, is a considerable task. Too often the patient is cared for and supervised during sickness, but is thrown weak and unfitted, upon his own resources to work out his economic readjustment. Many sanatorium patients are young, with limited education, have never worked, have no skill or experience, and need guidance in choosing an occupation, preparing for it and finding a place to work. Too laborious work may result in relapse. It is desirable to keep the recovered man well and restore him to the place in society for which he is best suited and where he can work with satisfaction to contribute to the general welfare.

Effort of the National Tuberculosis Association has been directed for several years to starting rehabilitation of patients during the recovery process. They need mental as well as physical treatment,—new lines of thought, new interests, encouragement, occupation to overcome worry and fill the time needed for recovery. Sanatorium routine is so planned that there is plenty of physical rest but mental interest is needed to stir the will to recover. Educational classes, academic, commercial and vocational are offered, even those confined to bed being able to "attend" by means of radio.

After study of a patient's family record, his past educational, vocational and avocational background and aptitude, a general program can be mapped for him to carry him forward in training for life and occupation. In some cases, he may be ready for placement by the time that he has recovered; others may need supplementary training and for them a Federal and state service is available. When training is completed, the federal-state agency steps in to aid in finding him a job where he can utilize the results of his training. W. Frank Persons, director of the U. S. Employment Service says that, "the specific abilities and fitness of the applicant must be considered and he is entitled to the attention necessary to give him special placement service." Public nurses and social workers are available to follow up the patient's progress after his recovery and ensure that it is continuous.

While taxes pay for and government agencies care for most sanatorium care and some public health activities, coordination of all activities into a smooth-working program for rehabilitation requires, in various localities, a trained liason officer and director, such work being undertaken by the National Tuberculosis Association. Christmas Seals help to pay for this work, as well as other activities in salvaging men by recuperation and rehabilitation.

An airplane view of the John Deere Tractor Plant at Waterloo, Iowa.

More Power For The John Deere Tractor Plant

THE NAME, JOHN DEERE, is one that is inseparably linked with the agricultural and industrial growth of the middle west. For a century the name has been a byword wherever agricultural implements are sold and in the early days before automobiles and chain stores there were few towns in the prairie states that did not have their John Deere agent.

John Deere, a young blacksmith, came to Illinois from Vermont to ply his trade and to build sawmills and other large works for the pioneers over a century ago. In this he was successful but his attention was soon directed to difficulties the farmers were having in plowing the rich prairie soil in Illinois and he set about devising a plow that would scour clean. So it was that in 1837, just one hundred years ago this year, John Deere in his small blacksmith shop fashioned the first successful plow for the sticky Illinois soil and thus laid the foundation for the great company which today still bears his name. Today, Deere and Co. operates eleven large manufacturing plants valued at approximately 150 million dollars.

One of these eleven plants, the John Deere Tractor Plant, is located at Waterloo, Iowa, and it is with the power plant at this factory that we are concerned here, particularly with a new 675 hp. boiler and a 2000 kw. turbine generator unit recently installed. Up to the time this new generating unit was installed, which was in January of this year, a considerable amount of electric power was purchased. Last year, for example, of the total 16,100,000 kw.-hr. used, over half or 8,300,000 kw-hr. was purchased. With the installation of the new generator, however, it is expected that the amount of power purchased will be materially reduced.

This plant was built in 1928 with 4 boilers, a 500 kw.

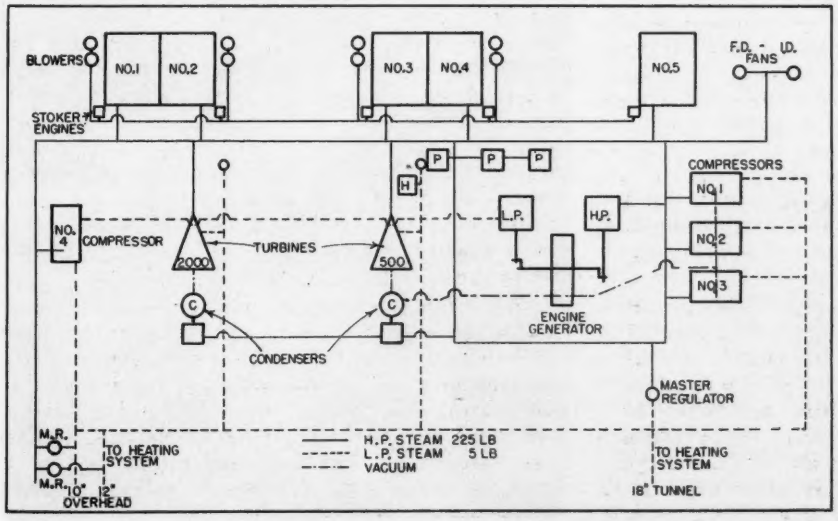


Fig. 1. The Steam Flow Diagram, showing the arrangement of the equipment and the high and low pressure steam lines. The two turbo-generators have surface condensers which are also connected to three of the steam driven air compressors

turbine generator, an engine driven generator and 4 steam driven air compressors. The compressed air load in this plant is quite heavy, the production last year amounting to 1,535,000,000 cu. ft. and until the new generator was installed the compressors took the major portion of the steam produced.

At the present time the plant consists of 5 boilers, 2 of which are rated at 525 hp. and 3 at 675 hp., one 2000 kw. turbo-generator, one 500 kw. turbo-generator, a 300 kw. engine driven generator and 4 air compressors.

The feature of particular interest about this plant which will probably appeal to other operators of industrial power plants is the unusually flexible arrangement provided for suitably proportioning the amount of exhaust steam produced.

The two turbines are mixed pressure, bleeder type units operating condensing. These operate from the 225 lb. mains as do the air compressors and the engine. A general idea of the piping arrangement may be obtained from the flow diagram in Fig. 1. This shows the 5 boilers, operating at 225 lb. delivering steam to the turbines, engines and compressors, all of which in turn bleed or exhaust into the 5 lb. low pressure lines. Reducing valves also permit the by-passing of steam from the high pressure to the low pressure system. The two surface condensers are shown together with the vacuum line to compressors No. 1, 2 and 3.

The factory contains some 350,000 sq. ft. of radiation so in winter, a large amount of low pressure steam is needed; in summer, on the other hand, only a comparatively small amount is needed.

During cold weather the heating system requires some 85,000 lb. of steam per hr., all of which is supplied as exhaust or bled from the turbines at a maximum of 6 lb. pressure. The exhaust piping is so arranged that it floats on the mixed pressure and bleeder turbines together with the exhaust from the air compressors thereby automatically maintaining the desired pressure.

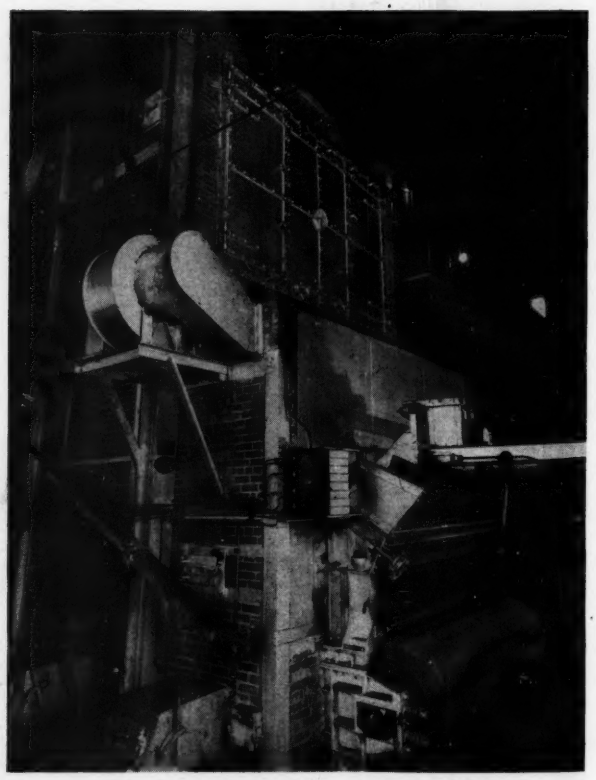
Three of the air compressors can be run condensing or non-condensing in connection with the mixed pressure and bleeder valves on the turbines. The arrangement is very flexible and permits great variation in the ratio between high and low pressure steam produced. With the two turbines and the three compressors operating condensing, the amount of low pressure steam produced is materially reduced.

The five boilers are set in batteries as shown on the flow diagram and in a row with their rear walls adjacent to the curtain wall between the boiler and engine room. All boilers are Springfield Boiler Co. units, Nos. 1 and 2 being rated at 525 hp., while Nos. 3, 4 and 5 at 675 hp., and all are fitted with Elesco superheaters and fired by Coxe stokers.

The four older units have simple refractory lined furnaces but the new unit has a rear arch and water walls. A cross section of this new unit showing the construction of the furnace and the arrangement of equip-

Fig. 2. (Left) A general view of the engine room showing the two turbo-generators in the foreground

Fig. 3. (Below) The new 675 hp. boiler



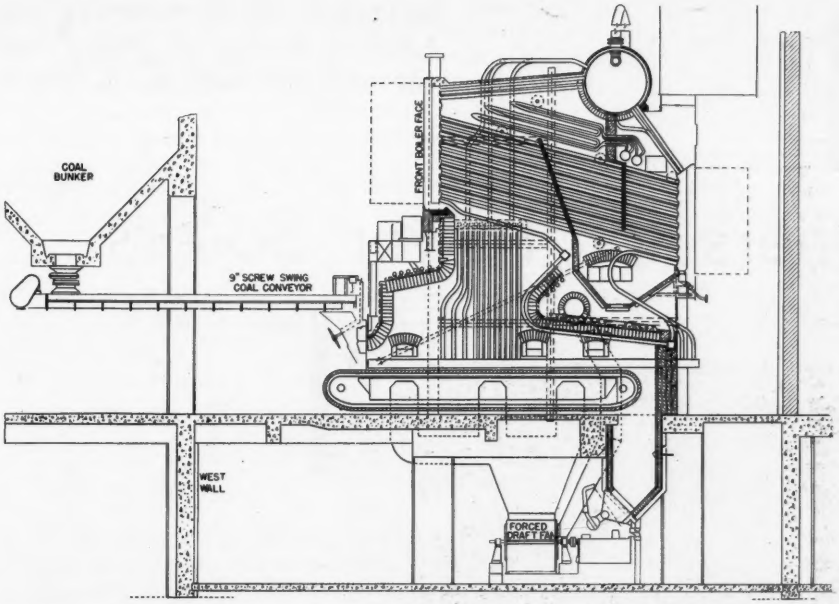


Fig. 4. A cross section of the new boiler showing the furnace construction and the coal handling arrangement. Coal from the bunkers is fed into each stoker hopper by an individual screw conveyor

ment is shown in Fig. 4. As shown, it is a single drum unit with baffling arranged for 3 passes and served by a horizontal breeching which is common to all boilers.

All boilers are equipped with direct connected Clarage steam engines for stoker drives, Copes feedwater regulators, Republic meters and draft gages. The blow-off valves are Hovalco, the soot blowers Diamond, and the water columns Reliance.

Forced draft for this new boiler is supplied by a Clarage forced draft blower driven by a Terry turbine and located in the basement as indicated. The four older boilers have individual Coppus turbine driven fans. Induced draft for all boilers is created by a 120,000 c.f.m. Green induced draft fan in the common breeching referred to and which is connected into a 10 ft. diam. 160 ft. high Heine concrete stack.

The coal handling system is simple. The stokers are fed from bunkers by individual Link-Belt conveyors as shown in Fig. 4. The bunkers are filled from the outside by a 2 t. traveling crane, which not only handles coal from cars to bunkers but also to and from storage.

Ashes are dumped from the ash hoppers under the boilers into narrow gage dump cars and delivered to an outdoor ash pit. The ash pit in the basement extends out under the crane so ashes are handled by the same bucket used for handling the coal.

Feed water for the boilers is obtained from Blackhawk Creek adjoining the plant. It is drawn through an intake fitted with a traveling screen by two vertical axiflow pumps supplying the entire plant. Condensate from the factory heating system is pumped from a receiving tank to two 4000-gal. surge tanks in the boiler room, to which make-up for the boiler is also supplied.

Three boiler feed pumps deliver water into a common feed line serving all boilers. These pumps are all turbine driven, centrifugal units controlled by Swartwout excess pressure regulators, but are of different make; one is a DeLaval unit, another a Dayton Dowd and the third, a Cameron pump. The 3000-hp. open feedwater heater is a Swartwout unit and as shown on the drawings, is located in the engine room.

The two turbo-generators are General Electric machines, one with a generator capacity of 833 kv-a., and the other, the new one, 2857 kv-a. These are served by Elliott surface condensers of 2100 and 2160 sq. ft., respectively.

The engine-driven generator, of course, is an old one, a Filer and Stowell cross compound engine direct connected to a 300-kw. Crocker-Wheeler alternator. This unit did long service in the old power plant and was

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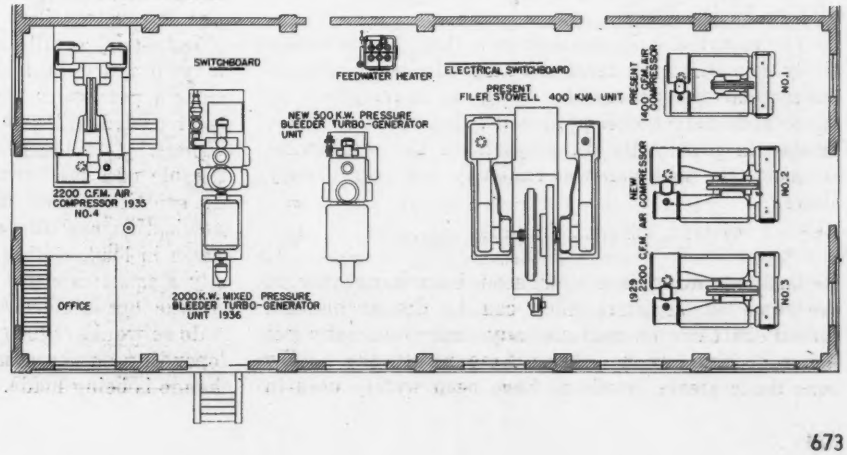

SWITCHBOARD
FEEDWATER HEATER
ELECTRICAL SWITCHBOARD
PRESENT FILER STOWELL 400 KVA. UNIT
NEW 500 K.W. PRESSURE BLEEDER TURBO-GENERATOR UNIT
PRESENT 1400 C.F.M. AIR COMPRESSOR NO.1
NEW 2200 C.F.M. AIR COMPRESSOR NO.2
1929 2200 C.F.M. AIR COMPRESSOR NO.3
2200 C.F.M. AIR COMPRESSOR 1935 NO.4
OFFICE
2000 K.W. MIXED PRESSURE BLEEDER TURBO-GENERATOR UNIT 1936

Fig. 5. A plan of the engine room showing the arrangement of equipment

Mistaken Opinions as to the Relative Merits of Steam and Mechanical Atomizing Oil Burners

Oil Burners for Power Boilers

By Kingsley L. Martin
President, The Engineer Co.

A COMPLETE misunderstanding and misstatement of the problems involved in the comparison of steam and mechanical atomizing oil burners has led to wholly erroneous conclusions as to their relative merits. For years a controversy has raged relative to the merits of the two methods of atomization when, as a matter of fact, the fight was not over the method of atomization but over the different methods used for admitting the air for combustion.

Steam atomization was understood to be a flat, fish tailed flame, projected into the furnace over checkerwork, through which the air for combustion was drawn by the chimney draft.

Mechanical atomization was understood, on the other hand, to be a hollow cone flame projected through an air register in the front wall of the furnace and the air for combustion, usually fan driven, was supplied through the register and around the flame.

With this set up, the mechanical atomizer with its hollow cone flame could be double banked and used in any desired number. With forced draft available, high capacities could be reached. On the other hand, with flat flame steam atomizers, double banking was impracticable because the lower row blanketed the air openings through the checkerwork and the upper layer of flame got little or no air. Forced draft was impossible as the air under pressure lifted without mixing with all of the flame.

The essential point to observe is that the discussion really concerned the method of air admission and not the method of atomization. With the development of steam atomizers which produced a hollow cone flame, similar in practically all respects to the mechanical atomizer, the situation was radically and immediately altered.

Atomizers Used Interchangeably

Both atomizers are now used interchangeably in the same air registers, they can be double banked, forced draft can be used and any desired capacity per boiler obtained with either. As a result, the hollow cone flame steam atomizers have been widely used in air registers designed for oil burning and in registers designed primarily for pulverized coal so that a true comparison, based on method of atomization and not on the method of air admission, is now possible and some interesting facts have been observed.

As to relative capacity, the limit is air for combustion and not atomizing capacity as 100,000 lb. of steam per hour per burner has been successfully developed. It has been found advisable, for other reasons to limit the capacity per burner to about 50,000 lb. steam per hour per burner for the average industrial plant.

As to range in capacity, with the mechanical atomizer, the fineness of atomization is dependent solely on the pressure at the burner, the higher the pressure the finer the atomization. To obtain maximum capacity, a sprayer plate with a suitable diameter orifice is used. To reduce capacity, the pressure is lowered and the atomization falls off until ultimately drops form, resulting in sparks in the flame, unburned oil on the floor and furnace walls, and drooling from the burner itself. In the Navy, when the pressure has been dropped about 50 lb., the atomizers are taken out and sprayer plates with smaller size orifices are substituted. The oil pressure is raised to maximum and the process repeated as the load falls off, except in manoeuvering, when part of the burners are shut off and started up in various boilers as needed. Long runs at constant load, however, are the rule.

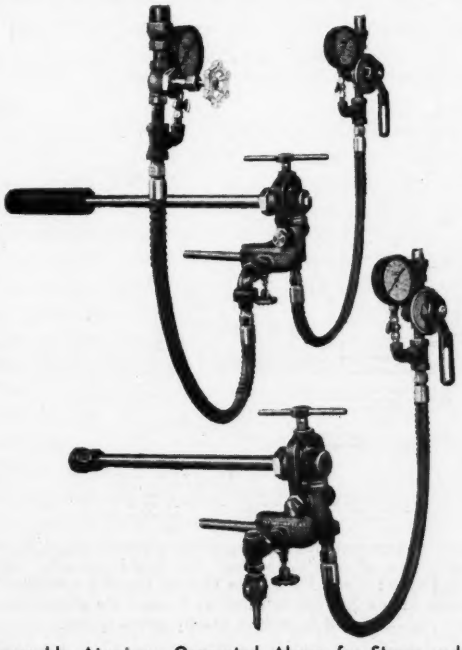
Industrial conditions are radically different. The Navy practice is toward a large number of small burners per boiler while land usage, especially with water cooled walls, is toward a small number of large burners. Consequently cutting out burners is objectionable and furthermore, if a falling load results in the substitution of small sprayer plates to maintain atomization and furnace efficiency, then a sudden increase in load, calling for every pound of steam, finds only a small capacity available and it is then no time to take out atomizers and change sprayer plates as to do so would reduce capacity one-half to one-quarter, depending on the number of burners in use while the change is being made.

With steam atomizers, the situation is different. All the oil pressure has to do is supply oil to the burners in the required amount and the atomization is efficiently performed throughout the entire range in capacity by the steam. The entire range, from pilot light to peak load, is instantly obtained by manipulation of steam and oil valves, either manually or by automatic control with no change in the atomizers themselves. This is one of the principal advantages of the steam atomizer.

Steam Atomizers Have Wide Range

However, with the wide use of pulverized coal and the use of oil for warming up, bringing on and taking off the line, banking, etc., as well as for carrying the station load at times, it has been necessary to develop atomizers of both kinds which will operate satisfactorily in air registers having coal cones, furnace throats and air blading designed solely with reference to efficient operation with coal and with no regard whatever for oil.

These burners are usually applied to large furnaces completely water cooled on all sides and having water screens over the furnace floor. Consequently there is little refractory to heat up and help combustion by its reflected heat. Under these conditions, it has been found difficult, if not impossible, to start these boilers cold, using mechanical atomizers, without dropping more or



Interchangeable Atomizer Connected Above for Steam and Below for Mechanical

less unburned oil on the furnace floor and depositing it on the side and back walls and there is usually heavy black smoke in the furnace and through the boiler tubes, superheater and air preheaters, if used, which soots up and insulates the heating surfaces and deposits unburned carbon where it may be later dislodged by soot blowers and constitute an explosion hazard. This smoke is difficult to clear up until the furnace gets thoroughly hot.

Under similar conditions, steam atomizers have functioned without any unburned oil in the furnace, the smoke clears up much more quickly and the sooting up is reduced, if not entirely eliminated. If compressed air, such as is commonly piped up to scavenge mechanical atomizers is used in steam atomizers temporarily substituted for the mechanical atomizers, the conditions are ideal as the flame burns clear from the start and there is no smoke, soot, unburned oil or flame impingement.

The principal and apparently the only disadvantage of the steam atomizer is the loss of steam used for atomization. Whether this is a determining factor or not depends on whether the feed make up water is evaporated or requires expensive treatment. With modern scientifically designed atomizers, the atomizing steam runs from 0.6 to 1.3 per cent of the steam generated. In any event, with mechanical atomizers, the higher pressure and temperature will require the use of additional steam in the pumps and heaters so that the actual difference in steam used for atomizing the oil, all elements considered, is usually not over one half of one per cent.

Sulphur in Oil

Another fallacy is that the atomizing steam will combine with the sulphur in the oil and corrode the boiler tubes, air preheaters or breeching. It must be realized that in any commercial fuel oil there is about 11 per cent hydrogen which combines in the furnace with the oxygen in the air for combustion forming water vapor. As a result, there is one pound of water vapor leaving the stack for every pound of oil burned in the furnace which ever method of atomization is used. Consequently the addition of say two tenths of a pound of steam used for atomization could not affect the total result.

More than that, it has been conclusively proved that the combination of sulphur and water vapor in the stack gasses has no corrosive effect on metal surfaces until the temperature has dropped below the dew point, said to be 250 deg. F. As stack gasses, even with air preheaters and economizers, seldom if ever reach this temperature while still in contact with metal, it is evident any fears on this score are unfounded.

It will appear from the above that both methods of atomization have their advantages and also their disadvantages and neither alone meets every situation in all kinds of power plants and it is a matter of engineering judgment which to use and it may readily be possible that it may be the best practice to so equip the plant that both steam and mechanical atomizers may be used interchangeably and one or the other used for short or long periods, depending on operating conditions.

Mechanical atomizers require that the oil should be heated until its viscosity is about 150 sec. Saybolt Universal while steam atomizers work well at 300 S.S.U. but they atomize even better and with less steam for atomization at the lower viscosity so that oil at 150 S.S.U. can be used for both which means the same oil temperature.

The mechanical atomizers require usually about 250 lb. at the burner for maximum capacity so as to get even a 2:1 range by reducing the oil pressure while about 90 lb. will give the maximum for steam atomizing. This difference in pressure can be taken care of at the burner by the adjustment of the fuel valve. So

that if an atomizer support is provided as shown in the illustration, with connections for steam and oil lines, cross connected for scavenging, which will take either a steam or mechanical atomizing gun, steam atomizing can be used for drying out, starting up, taking off, banking and up to full capacity with wide and rapid swings in load. When, however, a long steady pull is assured and the steam used for atomization becomes a factor, the mechanical atomizer can be substituted in a few moments.

Comparative Efficiency

The gross efficiency of the two methods, under test conditions of steady load, are substantially the same. To get the net efficiency, the loss of steam for atomization is balanced against the cost of higher oil pressure and higher oil temperature necessary for mechanical atomization. Under operating conditions with swinging load and resulting imperfect mechanical atomization, it is quite probable that the net efficiency of the steam atomizers is equal or superior to the mechanical as is indicated by summary of a year's operation in a representative plant having experience with both.

In general, public utility plants which can use the oil burning boilers for a base load at their maximum capacity, taking the swings on their less efficient units, prefer mechanical atomizers, especially when they evaporate their make up water. Among industrial plants, the operating men prefer steam atomizing on account of its wide range in capacity, simplicity of operation, greater freedom from furnace troubles, especially when used in pulverized coal burners. Many consulting engineers, having come to grief from having specified a wide range in capacity, under operating conditions and frequently with automatic control, have turned to steam atomization to secure the desired results. In both types of plants, however, as it is no longer necessary to make an irrevocable decision, once for all, which to use, it is becoming the established practice to equip for the use of either or both and then be prepared to meet any and all operating conditions as they develop.

Amendment to the Smoke Ordinance of the City of Chicago, passed July 29, 1937, provides for annual inspection of fuel burning equipment by the Department of Smoke Inspection and Abatement, and sets up a schedule of fees for annual inspections based on the capacity of equipment inspected. The amendment reads as follows:

"An annual inspection of fuel burning equipment for which certificates allowing the use of plant have been issued by the Department of Smoke Inspection and Abatement shall be made, to see that such equipment will do the work required and can be so managed that no dense smoke shall be emitted from the chimney connected to the furnace or firebox, in violation of the provision of this chapter."

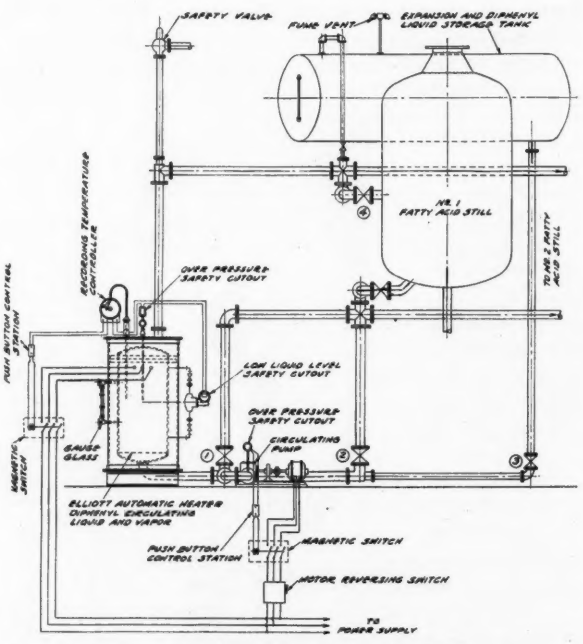
The amendment further provides for revocation of the certificate allowing operation of a plant, if it is found at the annual inspection that the equipment is in such condition that it cannot be operated without the emission of dense smoke in violation of the provision of the ordinance.

Process Heating

PROCESS REQUIREMENTS often demand a fixed and constant temperature but occasionally an unusual problem involving variable temperature comes up and must be solved to test the ingenuity of the engineer. An interesting installation of this kind was made recently by the Elliott Co. for an industrial plant processing industrial oils and fatty acids.

The temperature requirements were between 400 and 725 deg. F. An oil circulating system is suitable only for temperatures up to 600 deg. F. While diphenyl vapor can be used between 495 deg. F., the boiling point, and 750 deg. F. the upper limit set by the temperatures at which the vapor begins to break down.

To have operated both systems to get the desired range of 400 to 725 deg. F. would have made an expensive installation and the change over from one to the other and avoid contamination would have been im-



Schematic arrangement for utilizing either diphenyl liquid or vapor in conjunction with an electric heater. For liquid operation valve 1 is closed and valves 2 and 3 are open and the liquid is circulated by the small pump. For vapor operation valves 2 and 3 are closed and valve 1 is opened to make a gravity return system.

practical. The problem was solved by utilizing an electric heater in an arrangement shown by the drawing for using either diphenyl vapor or diphenyl liquid as operating conditions demand. Dowtherm liquid is circulated by the pump and in that way temperatures up to 495 deg. F. may be obtained. When it is necessary to operate at a higher temperature, the pump flow is reversed and the majority of the liquid is pumped into the expansion and liquid storage tank. Valve No. 2 is then closed, cutting out the pump and allowing the system to operate on vapor with the gravity return of condensate.

Pipe Connections to Heating Equipment

Troubles encountered with improper piping connections to and from the receiver tank of the condensate return system

By Thomas J. Brett

PROPER conditions for the vacuum requirements were not being maintained by the motor driven centrifugal pumping unit which had storage and circulating condensate tanks integral or in combination for the return condensate system. Vacuum was maintained at 5 to 10 in. and automatic control and regulation was provided for the continuous removal of the condensate.

This combination of pumping and receiver tanks was condemned as defective and obsolete, and it was believed necessary to replace this unit with a new type that would be adaptable for the adequate removal of the condensate with the application of 5 to 10 in. of vacuum according to the various operating requirements.

These defects caused considerable inconvenience, uncomfortable and unhealthy conditions, loss of production, large expenditures for operation and maintenance of the heating and processing equipment and a large expenditure for replacement of the equipment installed. The pumping unit was serviced by the makers or manufacturers of the unit and the personnel of the operating division.

This condensate return unit, Fig. 1, provided vacuum conditions with the application of nozzles of injector design using flow of water at high velocity from the centrifugal pumping unit for removal of the air and non-condensible gases from the heating systems and the processing equipment.

To provide this operating requirement, the condensate return unit was constructed with a receiver tank, a nozzle, and storage water sections for maintaining sufficient water and facilities for water jet action. The water jet nozzles had connections with the piping systems to the discharge section of the pumping unit and connections for water flow from the water jet nozzles to the water storage tanks.

The water level for proper operation of water jet nozzles and for the regulation and control of the vacuum application for condensate return was maintained by float, levers, a governing valve connected to the float and leverage system, a control valve with direct connected diaphragm installed on the pump discharge piping to the boiler units, and ⅛-in. control piping installed from and to the diaphragm valve, the governor and the condensate return piping connection to the storage tank. The governor valve provided passage for the air and the non-condensible gas from the condensate storage tank to the exterior spaces.

The ⅛-in. control piping from and to the diaphragm, governor, and the piping system was the cause of the first visit of the writer for correction of the operating defects of the pumping units. This unit was not producing proper vacuum on the condensate return systems. The condensate piping system was installed under the floor sections and below the pumping unit opening for condensate returns. This condition resulted in noisy operation, inadequate return of condensate, which caused low water in the boiler or considerable attendance to maintain water level and necessitated the drainage of the condensate manually.

The writer found the pump unit running continuously, the tanks without storage of water, and the condensate return system without vacuum conditions. Examination revealed that the defective operation was due to the changing of the ⅛-in. control piping connections at the governor and the obstruction of the openings and passages of the governor with corrosive substance from the condensate return system. This condition resulted in having the direct connected diaphragm valve remaining in open position due to spring action on the valve and the discharge of water direct to the boiler, thus eliminating the storage condensate that is necessary for the water jet action of the nozzles for the maintenance of vacuum in the condensate return system.

Governing and the maintaining of proper water storage and discharge are necessary for this type of pump and require proper adjustment of the starting and running periods which vary with vacuum and the quantity of condensate return, under the control of diaphragm and float operated electric switches.

The defective conditions that will cause a loss of vacuum for the condensate return, often the result of defects that are exterior to the vacuum maintaining equipment, are many and require the attention of the operating personnel. As an illustration, a small radiator was installed with connections to the main steam heating supply system and the condensate discharging to atmosphere. This installation, Fig. 2, caused a loss of vacuum on the entire heating system during periods when, due to light load, vacuum or sub-atmospheric conditions were extended to the steam supply

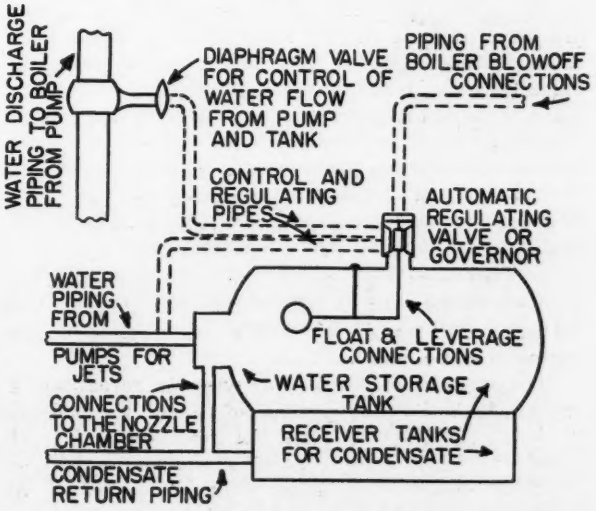

WATER DISCHARGE PIPING TO BOILER FROM PUMP
DIAPHRAGM VALVE FOR CONTROL OF WATER FLOW FROM PUMP AND TANK
PIPING FROM BOILER BLOWOFF CONNECTIONS
CONTROL AND REGULATING PIPES
AUTOMATIC REGULATING VALVE OR GOVERNOR
WATER PIPING FROM
FLOAT & LEVERAGE CONNECTIONS
PUMPS FOR JETS
WATER STORAGE TANK
CONNECTIONS TO THE NOZZLE CHAMBER
RECEIVER TANKS FOR CONDENSATE
CONDENSATE RETURN PIPING

Fig. 1. Condensate return unit connections

mains. This small radiator having connections to the atmosphere directly through the condensate opening resulted in air flowing to and through the trap, the radiator, and the piping systems, which resulted in complete loss or elimination of the vacuum conditions on the pumping and vacuum equipment. The elimination or leakage on the piping, valves, or radiation section of the heating systems is necessary for the proper operation and maintenance of the vacuum and equipment for condensate return.

An unusual piping connection which resulted in improper operation was that of the boiler blowoff

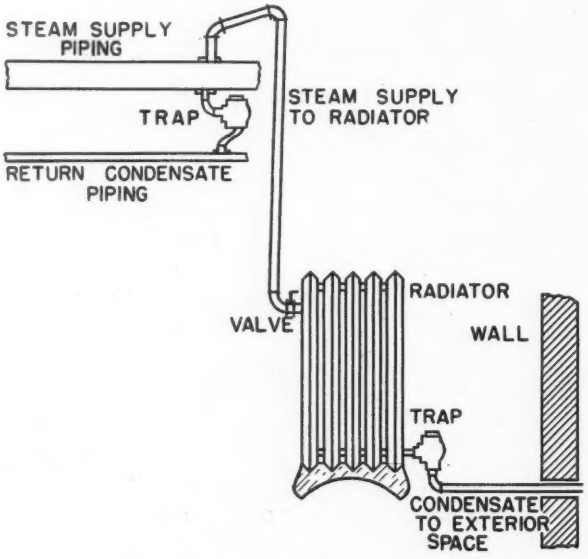


Fig. 2. Improper radiator connection which delivered air into steam supply line when operating at vacuum pressure

piping to air relief opening of the governor on the condensate return tanks. This connection prevented the elimination of the air and non-condensible gases from the condensate return system and resulted in the flow of blowndown water and sludge to the interior of the condensate return storage, which was delivered to the boiler in the cycle of operation.

To correct these difficulties, the blowoff piping was disconnected from the air relief opening of the governor installed on the condensate return pumping units, and the tanks and pumping units were provided with ample quantities of water for the operation of the water jet nozzles for the removal of the air and non-condensible gas from the condensate return. Now the equipment automatically maintains 5 to 10-in. of vacuum continuously and the heating system has proved to be adequate and noiseless in operation.

By remedying these three defectives in piping connections replacement of the vacuum condensate return units was found to be unnecessary.

IN COMPARATIVE tests of plain white iron and Ni-Hard nickel-chromium iron for centrifugal pump impellers at Copper Cliff plant, where the liquid handled contains 72 per cent solid matter and is highly abrasive, the alloy impellers averaged a life 2.39 times as great as the plain iron, with operating cost 0.7 that of the plain iron.

Ford Expands Power Plant

AN OUTSTANDING industrial power plant improvement program providing for increased output, lower production cost, and the use of some of the original equipment without enlarging the building has been undertaken by the Ford Motor Co. of Canada, Ltd., at its Windsor plant, with the engineering work being done by The Rust Engineering Co. of Pittsburgh, Pa. The immediate project will cost about $3,500,000 and provision has been made for further expansion in the future. When the present program is completed, the electrical generating capacity will have been increased from 15,000 to 35,000 kw., and the steam generating capacity from 300,000 to approximately 600,000 lb. per hr. The ultimate development to be undertaken in the future contemplates a maximum installation of 45,000 kw. and a steam generating capacity of 800,000 lb. per hr.

The development program now under way calls for the installation of three new boilers and two new turbines, one of which will be a topping turbine exhausting into the existing 10,000-kw. turbine.

In determining turbine throttle pressures and temperatures for the new equipment, studies were made for the present operating condition of approximately 200 lb., 600 deg. F.; 600 lb., 725 deg. F.; 800 lb., 800 deg. F.; 1,200 lb., 900 deg. F. The following table gives the principal results of this study:

	200 lb 600 T.T.	600 lb. 725 T.T.	800 lb. 800 T.T.	1,200 lb. 900 T.T.
Initial Investment in terms of a 200 lb. plant.....	1.00	1.30	1.40	1.70
Total Production cost in terms of a 200 lb. plant..	1.00	.914	.877	.888
Additional time required to pay off increased investment in years.....		3.49	3.25	3.66

The above figures were obtained by assuming an increase in both steam and electrical requirements over the present requirements. It will be observed that the 800 lb., 800 deg. F. total temperature plant has the lowest relative production cost, also that for the three higher pressures it would require the shortest period of time to pay for the added initial investment, on this basis, therefore, it was selected.

To provide the steam, three new three drum bent tube type boilers, designed for 900 lb. pressure will be installed. The boiler heating surface is 9,010 sq. ft., water walls 3,845 sq. ft., economizer 4,220 sq. ft. and air heater 9,940 sq. ft. Tangential firing is used with a pulverized fuel. Each boiler will normally provide 165,000 lb. of steam per hr. but auxiliary equipment has been provided for maximum short time ratings of 200,000 lb. or better.

The 5,000-kw. topping turbo-generator is designed to exhaust at from 175 to 200 lb., at 500 to 600 deg. F. into the existing low pressure 10,000-kw. condensing turbo-generator and in addition supply some of the steam for high pressure process use. A 20,000-kw. condensing double bleeding turbo-generator also is being installed. Both bleed points are automatically controlled so that, in addition to generating the electrical requirements, the turbine will furnish high pressure process or low pressure heating steam. Maximum bleeding capacities are 160,000 lb. of high pressure steam and 100,000 lb. of low pressure steam. In order to install this turbine, it was necessary to remove the old low pressure 5,000 kw. set.

High Pressure for the Steel Industry

New 525-lb., 700 deg. F. boiler plant at the Ohio Works of the Carnegie-Illinois Steel Co. described to the engineers of the Association of Iron and Steel Engineers at Chicago Convention. Two fuels can be burned separately or simultaneously and the arrangement contemplates later addition of topping turbines

By C. H. WILLIAMS
Asst. Chief Engineer
Carnegie-Illinois Steel Co.
Youngstown, Ohio

POSSIBILITIES of major future steam economies were anticipated at the Ohio Works of the Carnegie-Illinois Steel Corp., Youngstown, Ohio, by the recent installation of four 1750-hp. boiler units designed for ultimate operation at 525-lb. maximum drum pressure and 700 deg. F. total steam temperature. These capacities and steam conditions were selected for minimum cost of new units which would provide the maximum ultimate economy with topping turbines arranged to exhaust or bleed into the existing low pressure system and balance the supply of waste heat to the low pressure consumers.

The Ohio Works is the iron and steel producing unit of the Youngstown district plants and supplies semi-finished steel to the McDonald Works and Union Works finishing mills. The iron and steel works consists of six blast furnaces of which four or five active units supply the normal operating requirements of fifteen 120-t. open hearth furnaces and two 12-t. Bessemer converters. Two blooming mill units produce slabs, blooms and billets for trans-shipment to the finishing mills located some distance from the Ohio Works.

Prime Movers

Main steel works prime movers consist of reciprocating steam and gas engine blowers, the former using 150-lb. steam at limited superheat. In addition to this steam load, about 800 hp. of 150-lb. superheated steam is supplied to the Union Works through a 3700-ft. line. All a.c. power for the district is generated at 25 cycles in the Ohio Works plant by six gas engine generators, with a total capacity of 17,200 kw., and two 15,000-kw. turbo-generators designed for operation at 240-lb. ga., 540 deg. F. total temperature.

Previous to the installation of the new boilers, the steam generating equipment consisted of: A number of waste heat boilers operating at 150-lb. pressure; bent tube stoker fired boilers operating at either 250 or 150-lb, pressure as required; and, a number of scattered blast furnace gas fired boilers, producing 150-lb. saturated steam. These latter have been replaced by the new high pressure boilers first fired in April, 1937. Pending installation of the proposed topping turbines they are operated at 265-lb. pressure, steam being utilized in existing equipment with a piping arrangement such that only moderate modifications are necessary for adaptation to a two or three pressure system for ultimate operation at the higher pressure.

Water Cycle

This boiler program includes a water softening plant and essential auxiliary equipment illustrated by the feedwater cycle, Fig. 1. Clean water for boiler feed is first employed as a recirculating medium for gas engine cooling by which its temperature is raised to an average of 140 to 160 deg. F. depending on initial temperature and operating conditions. Feedwater makeup flows by gravity from the standpipe of this system to the softening plant where it is dumped into the jet heaters of a double tank hot process softener. Surface condenser condensate and softener effluent flow to the 1,000,000-lb. per hr. deaerator by gravity and thence to the high and low pressure feedwater pumps.

Steam pressure in the thoroughfare type deaerator is held constant at about 4 lb. by a control butterfly

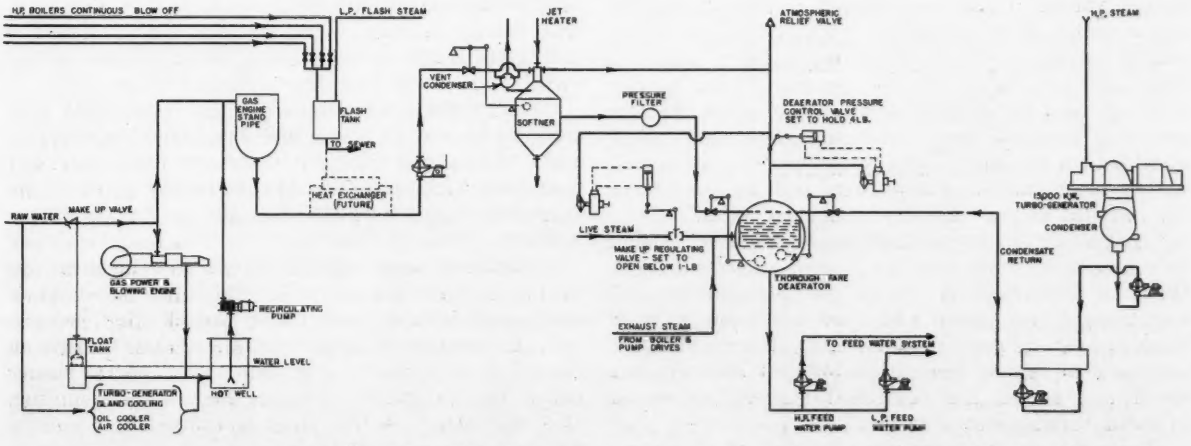


Fig. 1. Feedwater flow diagram of the Ohio Works plant. Waste heat from the gas engine jacket water is reclaimed in the feedwater makeup

in the exhaust steam outlet to the softener heaters. If exhaust steam from auxiliaries is inadequate for the softener-deaerator system, a live steam valve introduces steam to the deaerator inlet, in response to softener needs, at a pressure just above atmospheric. This valve closes off completely at a pressure below the atmospheric relief valve setting.

Figure 2 shows a cross section of the boiler house and indicates the general arrangement of boilers and main auxiliaries. Pairs of boilers on opposite sides of the house are of different manufacture and have minor variations in design details. Refractory lined steel plate ash hoppers with concrete bottoms are adapted to the bottom construction of each type boiler and are supplied with quencher sprays and oscillating type cleanout nozzles. The ash is sluiced off of a sloping bottom into an ash transport trench equipped with nozzles which convey the ash to an outside sump for drainage and disposal.

Water wall supply headers and mud drums of all boilers are equipped with 1½-in. double tandem seatless blowoff valves. Continuous blowoff is taken from the upper center drum of each boiler through graduated control valves; continuous blowdown is led to a 150-lb. flash tank tied in to the low pressure steam supply with provision for ultimate installation of a second stage recovery blowdown heat exchanger. The mud drums of all boilers are tapped with lines supplying secondary feedwater chemicals. Economizers and air preheaters are installed as heat recovery equipment on all boilers.

Turbine driven forced draft fans and geared turbine driven induced draft fans are located at ground level, the latter discharging to external steel plate stacks. All heat recovery equipment and ducts are insulated with block or built up panel type covering. Louvre dampers are installed in both fan outlets for shut off only; fan speed and output are controlled entirely by means of steam turbine control valves.

Inasmuch as the new plant is part of a general program for the utilization of waste fuel and the new boilers will be expected to use blast furnace gas, powdered coal was selected as the logical auxiliary boiler fuel. Combination coal and gas burners on all boilers are identical. They are the intertube type, firing between the spacing of the front water wall tubes.

There are two pulverizers installed on the ground floor below the firing aisle, each mill capable of developing full rating on one of the two opposite boilers. The mills, however, are spaced for the ultimate installation of two more units when required. Only one boiler at a time can be connected to either pulverizer. Coal is fed from duplex table type feeders on the operating floor level, discharging to opposite inlet ends of the double mill.

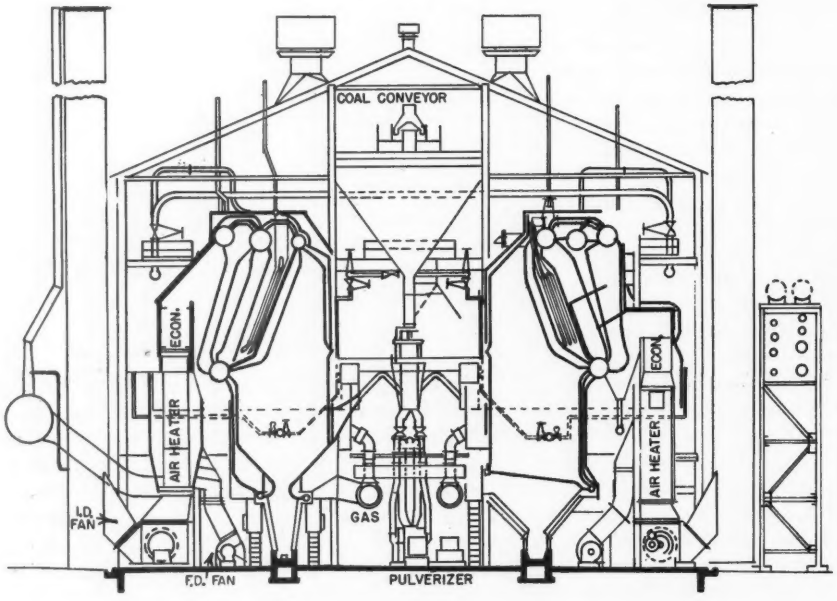


Fig. 2. Cross section of the new boiler house. There are four boilers, two on the right and two on the left. Each of the two pulverizers in the basement can fire the boiler on either side. Forced and induced draft fans are on the ground floor

Feedwater is supplied to the boiler through a sectionalized looped header. Individual boiler feed is taken through a single metering line which splits to dual feedwater regulator valves on opposite sides of the boilers located at the firing floor level. These lines reconnect at the economizer inlet. An intermediate deck at the economizer level gives access to economizers, mud drums, coal scales and desuperheaters. The top deck gives access to main steam valves, upper drums, water columns and feedwater regulator generators.

Due to the combination gas and pulverized coal firing which may be fired either separately or simultaneously, the control system is unusually interesting and complete. Because of its many interesting features, the combustion control will be described in detail in a later article.

Instrument and control boards are mounted on the firing floor in the side aisle. Individual boiler panels are located back to back facing their respective units with the regulators mounted behind these boards in the enclosure formed. The double-side, central master panel forms a similar enclosure for control mounting. One end section of this panel is utilized as a control station for main motor operated valves.

Air Conditioning for Industrial Workers

By Charles L. Hubbard

The effect of atmospheric and other hygienic conditions upon industrial production

IT IS A WELL KNOWN fact that the physical comfort of workers in industrial establishments has an important bearing upon both the quantity and quality of the output.

This effect will of course vary considerably in different cases, depending upon the class of goods manufactured, and the proportions of hand and machine work involved in the processes carried on. Again, the relation between hand controlled and automatic machinery is an influencing factor. In the case of hand work and hand controlled machines, slowing down will be due principally to physical fatigue, which in turn may be caused either by manual labor or bad atmospheric conditions. While the physical comfort of the operatives is of equal importance in plants making extensive use of automatic or semi-automatic machinery, production results are influenced more indirectly than in the cases noted. Here physical discomfort is more likely to manifest itself in industrial unrest, strikes, and loss of time through sickness.

Fatigue and Rest

In direct line with the foregoing, it is interesting to note some of the results of observations made in connection with fatigue and rest among industrial workers.

The sensation of fatigue, according to the commonly accepted theory, is caused by an excess of lactic acid in the system, due to physical exertion. Up to a certain point nature takes care of this condition automatically, but continued exertion causes this substance to accumulate, and unless the human chemical apparatus is given time to catch up, serious fatigue follows.

It seems to be a proven fact that the longer a person works continuously, the less he accomplishes in a given time; that is, the *rate* of doing work decreases. Production records usually show that after about two weeks' overtime a worker's output gradually diminishes until it becomes less than for an ordinary working day, and proves an actual loss to the employer, to say nothing of the injury to the health of the employee. This is leading more and more to the adoption of daily rest periods in certain industries and to shorter working hours in general as a means of increasing operating efficiency and the total monthly or yearly output.

The Effect of Atmospheric Conditions

Physical comfort depends largely upon the bodily temperature, and this in turn upon the relation between the rate of heat production and dissipation. In other words, to maintain a uniform temperature, which is essential to both comfort and health, it is necessary to remove heat from the body at the same rate that it is produced. Three principal factors affecting this condition are temperature, humidity, and air motion, and it has been found that within certain limits various combinations of these will give practically the same result.

The standard combination commonly taken for purposes of comparison is saturated still air at 70 deg. F. temperature, and an "effective temperature" of 70 deg. means any combination of temperature, humidity and air motion which will give the same degree of comfort. Some of the combinations which produce very nearly this result are given below:

Temperature, Deg. F.	72	76	76	80
Relative Humidity, %	82	39	75	42
Velocity, ft. per min.	0	0	200	200

In winter the greatest degree of comfort is experienced with an effective temperature of 66 deg., while in summer, due to the usual changes in clothing, it is found to be 70.5 deg. As the human body is able to adjust its heat regulating system to meet a considerable range of conditions without very much discomfort, the average person will find any effective temperature within these limits to prove satisfactory under ordinary conditions.

As a guide for securing these results with standard ventilating equipment, the following tables have been abridged from more elaborate ones published by the A. S. H. V. E. These cover a considerable range for both summer and winter conditions, with still air and a velocity of 200 ft. per min.

Table I. Summer Conditions. Still Air

Dry Bulb Temp. (degrees)	Wet Bulb Temp. (degrees)	Relative Humidity (per cent)	Effective Temp. (degrees)
70	70	100	70
72	64	65	68.9
72	68	82	70.3
74	62	51	69.2
74	68	74	71.4
76	60	39	69.8
76	66	59	71.7
80	57	21	70.8
80	62	36	72.3
83	59	21	72.8
83	64	35	74.3
86	61	22	74.7
86	64	29	75.7

Table II is prepared in a similar manner and covers a somewhat lower range of effective temperature adapted to winter conditions:

Table II. Winter Conditions. Still Air

Dry Bulb Temp. (degrees)	Wet Bulb Temp. (degrees)	Relative Humidity (per cent)	Effective Temp. (degrees)
66	66	100	66
68	58	66	74.8
68	62	72	65.9
70	52	26	64.5
70	58	48	65.9
72	52	21	65.6
72	58	43	67.0
74	53	20	66.8
74	58	37	68.1
76	55	19	68.4
76	60	39	69.8
80	57	21	70.8
80	60	30	71.7

In the tests made, results were determined for air velocities up to 700 ft. per min. Tables III and IV are for 200 ft., which would give a comfortable sense of air movement without disagreeable drafts.

Table III. Summer Conditions. Air Vel. 200 Ft. per Min.

Dry Bulb Temp. (degrees)	Wet Bulb Temp. (degrees)	Relative Humidity (per cent)	Effective Temp. (degrees)
72	72	100	68
74	64	58	67
74	70	75	68.8
76	64	52	68.1
76	70	75	70
78	64	47	69.4
78	70	67	71.3
83	59	21	70.9
83	68	46	71.8
86	61	22	72.9
86	66	34	74.4
90	63	20	75.5
90	66	27	76.3

Table IV. Winter Conditions. Air Vel. 200 Ft. per Min.

Dry Bulb Temp. (degrees)	Wet Bulb Temp. (degrees)	Relative Humidity (per cent)	Effective Temp. (degrees)
68	68	100	63.5
70	64	73	63.9
72	64	65	65.4
72	66	73	66.0
74	58	37	65.3
74	64	58	66.9
76	54	20	65.8
76	60	39	67.1
78	56	22	67.5
78	62	40	68.9
80	57	21	68.9
80	64	42	70.6

Air conditioning equipment is available for producing an effective temperature within the comfort zone for a considerable range of outside weather conditions by varying the combinations of temperature, humidity and air movement, as indicated in Tables I to IV. In addition to the matter of comfort, it has been found by extensive observation that not only is the production output increased by improvements in the atmospheric conditions of a plant but also the length of time between rest periods.

Air Cooling

In cooling the air of a room in hot weather, care should be taken not to create too great a difference between the inside and outside temperatures, else one will feel chilly upon entering. This applies more particularly to stores and similar spaces where people are constantly passing in and out. The result sought in cases of this kind is one of contrast rather than a fixed amount, and should not, in general, exceed about 10 deg. This, however, is subject to modification in certain industries and various special departments in manufacturing plants.

Power for John Deere Tractor Plant

(Continued from page 673)

moved to the new plant in 1928 where it is now used only for emergency or stand-by service.

The air compressors are all 2-stage, cross compound, Ingersoll-Rand units, Nos. 2, 3 and 4 being rated at 2200 c.f.m., while No. 1 is a smaller unit rated at 1400 c.f.m.

It will be quite obvious, from this brief description, that this power plant is well designed for the service it is called upon to render. In recent years it has been operating on a 24 hr. a day basis, with a high load factor, and this coupled with the continuous demand for steam, makes the problem of operation and maintenance one which requires constant attention.

The plant was built under the general direction of Einar Winholt, Power Engineer for Deere and Co. The chief operating engineer is Rubin Utterberg who has charge of its operation, maintenance and personnel under the factory superintendent Gust Olson Jr. As previously stated, up to the first of this year a considerable amount of electric power was purchased from the local utility unit, the need for outside power will be reduced. Last year, the output of the plant was as follows:

Electric power generated....	7,800,000 kw-hr.
Compressed air produced....	1,535 M.c.f.
Total equivalent kw-hr.	10,900,000 kw-hr.
Electric power purchased....	8,300,000 kw-hr.
Fuel consumed	35,000 tons
Steam produced	400,000,000 lb.
Heating system served.....	350,000 sq. ft.

Chicago Air Cleaned By Electricity

Pioneer Installation for Office Buildings to Serve Five Floors of the Field Building

APPLICATION of the electrostatic process of cleaning air for office buildings has been made for the first time in the Field Building, Chicago, Ill. This method, developed by the Westinghouse Research Laboratories, is capable of removing 99 per cent, by weight, of all particles in the atmosphere, even those which are as small as four-millionths of an inch in diameter. By this means it is expected that occupants of that section of the building furnished with treated air will be in an atmosphere free not only of all dust particles suspended in the air of the city, but even of annoying pollens from plants and air carried disease germs.

By this process, impurities are taken from the air by charging all particles electrically and thus pulling them out as they pass through an electrostatic field, in a manner similar to that by which a magnet attracts iron filings. In this cleaning process the air is first bombarded by ions emitted by extremely fine wires which carry a charge of 12,000 v. The ions attach themselves to particles in the air, thus giving the particles an electrical charge.

Next the treated air is drawn through a series of cells consisting of alternately spaced high-potential and grounded plates. By charging the high-potential plates at 5000 v. an electrical field is established. As the treated air passes through these cells, the charged particles adhere to the plates and the air so freed of all solid matter passes through ducts that lead to the areas being served by the equipment.

The precipitator consists of a system of cells made up of flat aluminum plates. In each cell are 111 plates, each 8 in. by 9 in. in size. The Field Building system includes 369 cells or 40,959 plates. The tungsten ionizing wires are but 0.005 in. in diameter and nearly half a mile of this wire is required for this installation. Dirt collected by the units is cleaned off every month or six weeks.

Eighteen units have been installed in the Field Building which are capable of cleaning 272,000 cu. ft. of air each minute. From calculations, it is estimated that in a year's time the installations will have collected approximately 600 bu. of impurities. By weight, the collection will consist of one-third ash; another third fixed carbon, soot lampback and other derivatives; and the remaining third volatile matter such as oils and greases. Sulphur, bacteria, pollen in season and other substances found in suspension in the atmosphere of any city are also deposited on the plates.

Fig. 1. View showing the location of three electrostatic air cleaners, power packs and door switches in the Field Building

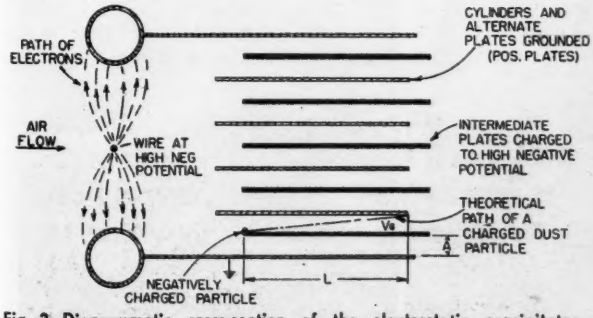


Fig. 2. Diagrammatic cross-section of the electrostatic precipitator showing the collecting plates and path of charged dust particle

Fig. 3. Air to be cleaned enters this side of the 22,500 c.f.m. air cleaner which is composed of 30 collection cells

Oxy-acetylene Repair of Turbine Saves $2000.

Cast Bronze Patches to Replace Worn Fins Welded Into Place

A CAST BRONZE water wheel, or runner, which had been in service for about 16 yr. in a hydroelectric power plant was removed for repairs. During this period of operation considerable wear had resulted. Erosion had caused the fins, originally 3/8 in. thick, to wear down to about 1/16 in. Rocks had gone through the wheel, breaking and cracking some of the fins.

When the wheel was removed from the turbine it was found that 17 of the 22 fins were in need of repair. Those parts of the fins that had to be replaced were removed by melting them out with the oxy-acetylene blowpipe. The edges that were left after the sections had been melted out were ground down smooth and thoroughly cleaned off. New fin sections were cast to replace the parts of the 17 that were no longer any good.

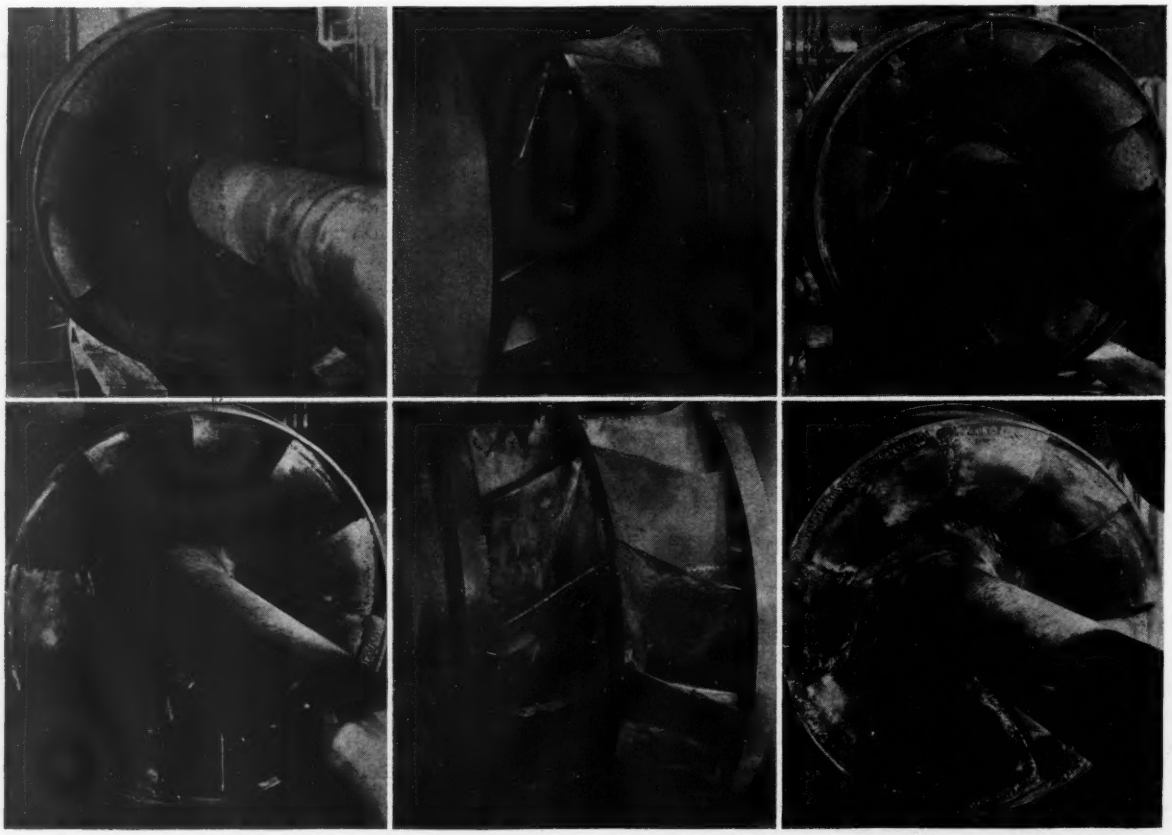
It was impossible to remove the 2,000-lb. wheel casting from the 8-in. diameter drive shaft. Boxings were built sufficiently high to support the shaft and wheel off the floor and make it possible to turn the entire casting. It was then thoroughly wrapped in asbestos paper and preheated slowly.

Each fin required about 30 linear in. of welding. High-strength bronze welding rod was used. As the heavy sections were worked on, the flames of two extra blowpipes were utilized to keep the casting at the proper temperature and avoid distortion.

It was estimated that by welding in patches, at least $2,000.00 was saved over the cost of a new runner.—"Oxy-Acetylene Tips".

Top row, left to right—
The inboard end, the center, and
outboard end of the water wheel before repair

Bottom row,
left to right—Inboard end,
center, and outboard end after repair



STEAM JET REFRIGERATION

This versatile method of cooling has many industrial applications but requires careful calculation*

By A. A. BROWNE

Industrial Division Westinghouse Elec. & Mfg. Co., Portland, Ore.

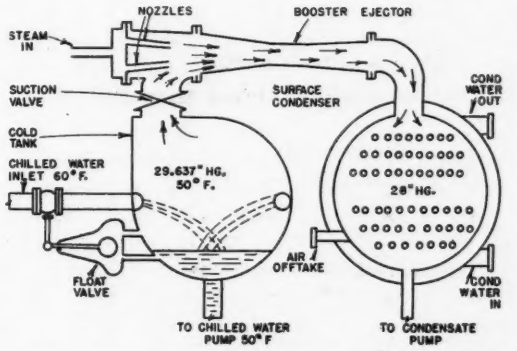


Fig. 1. Schematic arrangement of a simple steam jet refrigeration unit

VACUUM REFRIGERATION dates back as far as 1755 but it was not until the advent of air conditioning that this type of equipment came to the front. Machines as large as 600 t. in a single unit are now in service.

It has many advantages: No moving parts; freedom from noise and vibration; negligible maintenance; simple cycle of operation; flexible design which fits into unusual space limitations; will utilize available low pressure steam; the inexpensive refrigerant, water, does not give off undesirable odors and is always available; small space requirements; with a number of booster ejectors in parallel the part load efficiency is practically the same as at full load; in air conditioning, if air washers are used, no heat exchanger is necessary between the refrigerant and the washer since the refrigerant (water) can be pumped direct to the washer.

Limitations of the steam jet vacuum cooler are: It cannot be used to produce temperatures below 32 deg. F. unless brine is used for the refrigerant; it will not carry part load at steam pressures less than that for which it was designed unless the decrease in steam pressure is compensated for by an improvement in condenser vacuum; nor will it function if the operating vacuum is allowed to decrease, unless compensation is made by increasing the steam pressure.

Simple Unit

In its simple form a steam jet vacuum cooler consists of an evaporator (sometimes called a flash chamber or cold tank), a steam jet compressor (usually called a booster ejector), and a condenser of either the surface, jet or barometric type all arranged as shown by Fig. 1. Live steam is conducted to the booster ejector and is expanded through one or more nozzles and is discharged at a high velocity of approximately 4500 ft. per sec. The high velocity steam jets entrain water vapor from the cold tank and the mixture of water vapor and propelling steam is compressed in the body or diffuser of the ejector and then discharged into the condenser. An air removal apparatus and a condensate pump serve the condenser to keep the air tension down to a minimum and to remove the condensed steam and vapors.

The cold tank is usually constructed of mild steel with all seams, flanges and bracing electrically welded to produce a vacuum tight vessel. It is equipped with a liquid level controller which regulates the flow of water through the spray heads. These heads may take a number of forms but in each case the object is to discharge the water into the flash chamber in whatever form which will expose the largest evaporating surface compared to the volume. The design should provide for the minimum amount of mechanical carry-over of free water with the vapors. This mechanical carry-over can be minimized by providing large passages so that the vapor velocity is kept low. A pipe connection is made in the bottom of the cold tank so that the chilled water may be drawn off by means of a pump.

The booster ejector is the heart of the steam jet vacuum cooler and the body or diffuser and mixing chamber are usually constructed of cast steel, welded mild steel or special materials depending upon steam conditions. The nozzles themselves are made of manganese copper, stainless steel, monel metal or other special materials. For the best economy of steam consumption the nozzles should be as far back from the throat of the diffuser as possible and still maintain stable operation. Fulfillment of this high efficiency con-

*This is part of a paper presented before the Pacific Coast Convention of the N. A. P. R. E.

dition sometimes makes the starting of the unit difficult so a starting nozzle is used, located farther out in the diffuser. This nozzle is shut down as soon as the running nozzles have been placed in operation.

There are three ways in which each booster ejector may be segregated in order to operate the unit at partial load: By compartments in the cold tank; by compartments in the condenser; by suction valves at the outlet to each booster ejector. Of these, the use of suction valves provides for the greatest potential savings in steam and condenser water, if the temperature or load is less than the maximum for which the unit is designed. In many types of installations it is desirable that the full quantity of chilled water be circulated continuously, regardless of load variations. Any attempt to segregate the cold tank into compartments

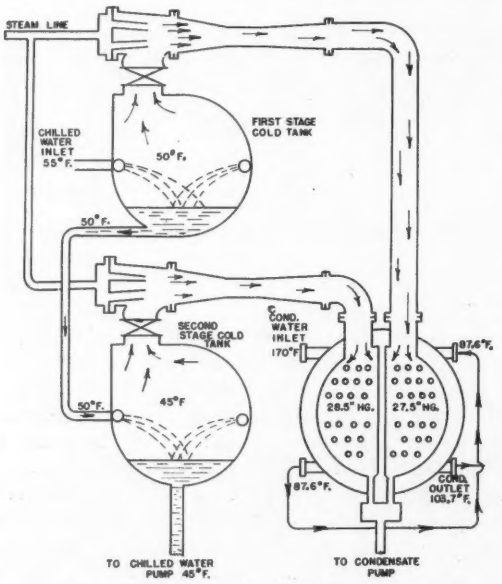


Fig. 2. A two stage unit gives better economy

seriously interferes with and usually prevents this full circulation.

Compartments in the condenser prevent the use of the entire condenser surface when running on partial loads or with colder than maximum condenser water. Under either or both of these conditions, the condenser is capable of a higher vacuum than normal for the booster. Then, under the above conditions, considerable saving can be had by either throttling water to the condenser or throttling steam to the boosters, which ever produces the greatest savings.

Surface type, shell and tube condensers are used in the majority of applications. These units are similar to those used for steam turbines except that 4 to 6 water passes are used in order to conserve on water. A barometric condenser may be substituted for the shell and tube type if the location will permit a barometric leg of approximately 40 ft. Such an arrangement is usually lower in first cost and will give as good performance as a surface condenser.

Presence of air in the condenser will spoil the vacuum unless means are used to remove it. The most common form of air removal apparatus consists of a two stage steam ejector arrangement with a small condenser interposed between stages. An "after" condenser is usually used to condense the exhaust of the second stage jet, although is not entirely necessary because it exhausts at atmospheric pressure. This two stage air ejector is not economical at steam pressures less than approximately 60 lb. ga. For lower steam pressures, a single stage air ejector exhausting into some type of water sealed air pump is usually used.

A steam jet vacuum cooler can be designed to operate successfully at any steam pressure above about 2 lb. per sq. in. ga. Little improvement in efficiency is obtained at pressures above 125 lb. per sq. in. and although dry steam is essential, the use of superheated steam is not recommended since it only imposes an additional burden on the condenser.

This type of equipment will not work under conditions differing much from those for which it was designed, so it is necessary to have accurate knowledge of: Steam pressure at the unit and the quantities available; temperature to which the chilled water is to be cooled; maximum temperature of the condenser water and the quantities available; cost of condenser water in dollars per 1000 cu. ft.; cost of steam in dollars per 1000 lb.

For any assumed chilled water temperature, the quantity of steam decreases as the condenser vacuum improves and the quantity of condenser water required increases with an improvement in condenser vacuum. Since the steam and water consumption vary with the condenser vacuum it is necessary to consider the relative costs of these items in order to arrive at the operating vacuum which will give the lowest combined cost.

As the steam pressure decreases the steam consumption increases approximately as follows: At 60 lb. it is approximately 12 per cent greater than at 100 lb.; at 40 lb. approximately 20 per cent more than at 100 lb. and with 2 lb. at the nozzles the steam consumption is about 85 per cent greater than at 100 lb.

Multi-Stage Cooling and Multi-Stage Condensing

Better economies than those of the standard units can be obtained by using two or more evaporators in series. The water to be chilled is introduced into the first evaporator and is cooled through part of the desired temperature range. Then it enters the second evaporator and is cooled down to the final temperature. Such an arrangement is called two-stage cooling single stage condensing (providing the boosters of each evaporator exhaust into the same condenser at the same vacuum).

Improvements in economies can be obtained by staging either the evaporators or the condenser sections and still better results are obtained by staging both. Still greater economies are possible by increasing the number of stages but this complicates and enlarges the physical size of the equipment. Improvements in economies that can be obtained under average conditions are shown by the table.

Economies Expected from Staging in Steam Jet Refrigeration

Number of Stages Cooling	Number of Stages Condensing	Per Cent Consumption of Single Stage Unit	
		Steam	Water
1	1	100	100
2	1	92	94
1	2	91	91
2	2	86	86

Chicago Views Power Development

Approximately 150 exhibitors gather at the International Amphitheater, Oct. 4 to 9

UNDER THE AMPLE RAFTERS of Chicago's International Amphitheater, middlewestern engineers gathered during the week of October 4 to 9 to view the latest developments of some 150 exhibitors. With the official title of the Exposition of Power & Mechanical Engineering, it was something of an innovation, for, although power shows have been a prominent engineering feature in Chicago for more than a decade, this was the first one under the same management as the New York Show.

Heavy equipment such as boilers, turbines, pulverizers and large stokers were absent but there was a definite power plant atmosphere to the show, something that has been lacking during the depression years. A large part of this was due perhaps to the large number of extensive valve exhibits all reflecting the recent trends toward high pressures and temperatures.

Alloy steel bodies with stainless steel and Stellite trims were much in evidence although all valve exhibits were unusually complete and covered the entire range from low to high pressures. Crane Co. displayed many of its varied line of products with interest centered in an extensive display of different type valves and welding fittings. The Edward Valve & Mfg. Co. featured a chromium plated 900-lb., 900 deg. F. stop valve with an Impactor handwheel displayed against a background of other valves, parts and cut-a-ways. Jenkins Bros. showed many of its larger valves, the central one a 600-lb. steel body globe valve with Stellite trim.

Some of the larger valves shown were motor operated. The Reading, Pratt & Cady Div. of the American Chain & Cable Co., Inc., built its exhibit around a 1500 lb., 8-in. valve with a Limitorque Control set up so that visiting engineers could operate it. Walworth Co. too had a motor operated unit, a 10-in. alloy steel valve with a Cutler-Hammer control and intended for operation at 1350 lb., 980 deg. F.

Condenser tubes were prominent, more so than any show for many years. The American Brass Co. showed a wide range of Anaconda alloy tubes made by different methods. Bridgeport Brass Co. featured its laboratory testing equipment for air impingement attack and showed microphotographs of various alloys tested. Revere Copper & Brass, Inc., had an extensive illuminated display of the various steps in the extrusion method of manufacturing seamless tubes. Wolverine Tube Co. too emphasized the extrusion method of manufacture of condenser tubes and also its All-In-One finned tube of copper and aluminum in which the tapered fin is extruded from a portion of the tube wall of seamless tubing. Condensers themselves were featured by but one manufacturer, C. H. Wheeler Mfg. Co., where, in the booth of Faville-Levally Co., was shown an illuminated condenser section and a full size Tubejet vacuum pump.

Closely allied to these were the boiler tube exhibits. Jones & Laughlin Steel Corp. showed seamless boiler tube and pipe and various steps in its manufacture. Steel & Tubes, Inc., featured its new Electronite resistance welded boiler tubes and demonstrated the strength and ductility of the weld on a small testing machine in the booth. The Youngstown Sheet & Tube Co. left boiler tubes in the background and featured recent plant improvements which include continuous hot and cold reduction mills.

Boiler tubes, however, were not alone among boiler auxiliaries and appurtenances for the boiler room was well covered. In the booth of D. H. Skeen & Co. an operating model of the American Pulverizer Co. Rolling Ring crusher demonstrated the proper preparation of coal for the power plant and a model of the Johnston & Jennings Co. Stowe Compensating feed stoker showed how the same coal can be burned economically. Link-Belt Co. too featured stokers but of the smaller underfeed type arranged in an extensive display of its products of elevating and handling equipment, chains and speed reducer units. Wright-Austin Co. displayed its complete line of steam specialties.

Coal Handling

In another aisle the Stock Engineering Co. demonstrated the action of its Conical Coal distributor but featured its new dust and drip proof Seco coal valve. Next to this, The Louden Mach. Co. demonstrated its monorail system for filling stoker hoppers. Connery & Co. had a number of small scale models showing the application of its Improved Expansion Stiffner to breechings, uptakes and air ducts. Prat-Daniel Corp. featured cyclones for cinder and fly ash removal but did not forget a model of its Thermix Stack.

Oil burners were also represented but by a single exhibit, that of the Ray Oil Burner Co. The Hays Institute of Combustion was there to point out that equipment is but part of the picture and knowledge of, how to get, the most efficient combustion is equally important.

Furnace refractories were not as numerous as they have been in the past but what was lacking in quantity was made up by the quality of the exhibits. The A. P. Green Firebrick Co. featured special shapes and plastic refractories and application of the former to a section of Bigelow-Liptak Corp. unit suspended wall. Plibrico Jointless Firebrick Co. showed numerous plastic applications, particularly the Plibrico suspended arch. The Ramtite Co. emphasized the ease of application of plastic refractories by means of air hammers and the construction of its sectionally supported walls with refractory anchors. Geo. P. Reintjes Co. demonstrated its wall and arch constructions in a special composite demonstration unit.

Feedwater presents one of the major problems of the modern plant. An operating model of its Two-Flo

Zeolite softener was featured by the Elgin Softener Corp. Control of scale and corrosion by organic methods formed the basis theme of the D. W. Haering Co., Inc. exhibit. Nalco softening and water testing equipment was emphasized by the National Aluminate Co., but the main feature was its new Nalcometer for the determination of total dissolved solids in boiler water for purposes of concentration control.

Insulation

Forty-Eight Insulations, Inc. showed various steps in the manufacture of its products from slag. Johns-Manville featured "Barriers to Industrial Waste," its entire line of insulations, packing and Transite. Keasbey & Mattison Co. too featured its entire line of asbestos and magnesia products in all forms by moving displays. At its booth F. E. Schundler & Co., Inc., made its Vermiculite insulation from a mineral mined in Montana and showed its various final forms in sheet, brick and plastic. Steam line underground insulation was represented by the Durant Presealed insulated pipe system of the Ehret Magnesia Mfg. Co. and by the various conduit constructions of the Ric-Wil Co., the latter demonstrating the effectiveness of its Drypack insulation against moisture absorption.

E. B. Badger & Sons Co. had a moving exhibit to show the effective action of its Directed Flexing Self equalizing expansion joint for all types of low and high pressure pipe lines. Parker Appliance Co. showed the application of Parker tubing and specialties in the power plant emphasizing especially the application to instrument panels. Beaver Pipe Tools, Inc., featured the utility of its Model A portable pipe and bolt machine for power plant maintenance and construction. Toledo Pipe Threading Mach. Co. displayed its line of pipe threading machinery and The Oster Mfg. Co. its Tom Thumb portable pipe machine. Prefabricated piping and welding fittings and pipe hangers were displayed by Grinnell Co., Inc., the feature of the exhibit being a large Genspring Hanger supporting a pipe section weighted to 1200 lb. and arranged so it could be moved by visitors to show the action of the hanger. Closely allied to piping, metal hose has become of increased industrial importance and the steel and bronze exhibit of Rex-Weld corrugated metal hose has become of increased industrial importance Hose Corp. was unusually complete.

By means of operating glass models, Armstrong Mach. Wks. demonstrated the action of its inverted bucket trap in handling large quantities of air in addition to the removal of condensate. Operation of the Coe Drainator was shown in the booth of The Coe Mfg. Co. Yarnall-Waring Co., although having an extensive display of Tandem Seatless and forged steel blow off valves for pressures up to 1500 lb., water columns, gages, spray nozzles and Gun Pakt expansion joints, featured its complete line of the new Impulse steam trap.

Engines and Compressors

One of the largest pieces of equipment displayed was a Model 1700 Diesel of the Caterpillar Tractor Co., a V-type, eight cylinder unit rated at 160 hp., the latest and largest of its line of engines. Among a display of roller bearings ranging from the smallest to the largest, The Timken Roller Bearing Co. featured its new fuel injection pump for Diesels with an operating model partially cut away so as to show both the construction and operation. Sullivan Machinery Co. too showed heavy equipment, the central feature being a full sized WN 12 compressor of compact two cylinder design for either direct engine or motor drive.

Power transmission equipment came in for a great deal of attention. Allis-Chalmers Mfg. Co. Texrope drives and Rockwell Pulley Co., pivoted motor bases were features of the Chicago Belting Co. exhibit. Various arrangements of V-belt drives were also shown by The Dayton Rubber Mfg. Co. together with a special demonstration of the Daycoil oil proof belt. J. E. Rhoads & Sons had special belt testing equipment installed to show the comparative performance of rubber, regular oak tanned leather and its special Tannate leather belts under different tensions and slips.

Speed reducing units and speed changers were much in evidence. Cleveland Worm & Gear Co. featured its worm gear reducers. The Philadelphia Gear Works also made a feature of its speed changers. The new J. F. S. Jr., vari-speed control was demonstrated in operation by the Columbia Vari-Speed Co. Reeves Pulley Co. had an extensive display of its various speed changer units and placed particular emphasis on the Reeves Motodrive. Graham Transmissions, Inc. featured the construction and operating principles of its variable speed transmission. Ball and roller bearings are now necessary adjuncts to modern equipment so the Ahlberg Bearing Co. made a feature of its new line of C. J. B. transmission units designed primarily to meet plant modernization needs.

Couplings and Clutches

Various types of flexible couplings were displayed by the Lovejoy Flexible Coupling Co. Morflex Couplings and chain drives were shown by The Morse Chain Co. but the feature of this booth was the Kelpo free wheeling clutch and the Morse High Torque Indexing and free wheeling Clutch.

Instruments and controllers were shown in a number of booths. Barrett-Christie Co. had an operating exhibit demonstrating the application of the Bender-Warrick Corp. Induction Relay to floatless pump control; the Johnson Corp. two valve trap; and Mason-Neilan Reg. Co. indicating and recording instruments and controllers. Mayer & Oswald, Inc. displayed the Meriam Co. manometers and flow meters; the coal level controller of The Bindicator Co., and the L. J. Wing Mfg. Co. new Type COM two stage blower. Sarco Co., Inc., made a feature of its various types of traps for pressures up to as high as 500 lb. but in an addition had an extensive exhibit of its temperature controls and regulators, the new scraper cleaned strainer and a working exhibit of steam and water mixing valves.

As might be expected most of the control equipment was electrical. Allen-Bradley featured its New Bulletin 709 solenoid motor starter. Cutler-Hammer, Inc. displayed safety switches, motor starters and electrical specialties around a central exhibit of automatically operated light dimmers.

Among other products Ward-Leonard Elec. Co. exhibited its electronic automatic voltage regulator. Westinghouse Elec. & Mfg. Co. displayed a variety of

equipment including a splash proof motor operating in a water spray, type M industrial turbine and CSP transformers, but the feature of the exhibit was the sensitive breath relay. Weston Elec. Instrument Corp. too displayed a wide variety of equipment in which its industrial analyzer, the light cell and electric tachometer, the new line of industrial temperature gages for temperatures up to 1000 deg. F. seemed to create greatest interest among the spectators. Veeder-Root, Inc., displayed many different types of counters in operation and featured the electric operated remote indicating type. Industrial lighting by means of Cooper-Hewitt lamps was the central theme of the General Electric Vapor Lamp Co. exhibit.

Elimination of dust and finely divided material from air by its new Roto-Clone water spray dynamic precipitator was demonstrated by the American Air Filter Co. Air filters of many types were shown by the Staynew Filter Corp. Carrier Corp. featured the use of its centrifugal refrigeration units in combination with existing ammonia systems. The display of the Chicago Rawhide Mfg. Co. centered around its Perfect oil seal for rotating shafts. In an extensive display of packings of various kinds Garlock Packing Co. too featured seals for rotating shafts, its Klosures for either oil or grease.

Unit and blast heaters manufactured by the Modine Mfg. Co. were shown in cut away forms to show the construction and provision to take care of tube expansion without transmitting stresses to the shell and headers.

Advantages and application of industrial paints of the flake silica-graphite type and graphite products for general industrial use were emphasized by the Jos. Dixon Crucible Co. Snap-on Tools, Inc., had an exhibit of universal application to all equipment used in the plant, modern wrenches of all types with their use illustrated by illuminated photographs showing how to save time and effort on assembly and maintenance jobs.

Red Cross First Aid Taught in Industry

EACH YEAR many lives are saved and much suffering is spared victims of accidents because someone on the scene of an emergency has received training in Red Cross methods of first aid and can give help intelligently. The first aider does not attempt to give the help of a physician, but in many instances this layman's immediate assistance keeps an accident victim alive until the services of a doctor can be procured.

That the American Red Cross has been intensely interested in the welfare of those employed in factories is shown by the number of factory employes who have received certificates from the Red Cross upon the completion of first aid courses.

Mine workers in a little Pennsylvania town were responsible for the entry of the Red Cross into the first aid field. Back near the turn of the century a small-town physician was appalled at the number of permanent injuries resulting from mine accidents, and determined to teach first aid as a means of giving the mine workers some weapon with which to combat the large number of deaths and permanent injuries resulting when the services of a doctor were not immediately available.

His classes were successful. Deaths and injuries from accidents decreased. A national officer of the Red Cross became interested. The physician responsible, Dr. M. J. Shields, was invited to come to Washington and plan his work on a national scale. As a result, 1,430,000 persons to date have received first aid certificates upon completion of courses under Red Cross instructors.

Experience where first aid training has been given to key groups of employes indicates that safety thinking and first aid go hand in hand. When workmen learn the possible seriousness of even minor injuries through a study of first aid they are much more likely to avoid accidents than those who have not had the advantage of this training. As a result, industrial statistics show that the accident frequency rate among first-aid-trained groups is much lower than among non-trained groups doing the same work.

Teaching of first aid, as carried on by thousands of Red Cross Chapters in all parts of the United States, is supported by the membership dues of persons who join the Red Cross during the annual Roll Call, held from Armistice Day to Thanksgiving. Not only first aid, but all other Red Cross programs, such as preparedness to give help in disasters, instruction in water life saving, public health nursing and instruction in home care of the sick, assistance to war-disabled veterans and men in active service, the making of clothing for needy families and books in Braille for the blind, are all supported by membership dues. Enrollment as a Red Cross member from November 11th to 25th will aid these activities.

Moisture in Compressed Air

Efficiency of air tools is greatly reduced by moisture in the air; several methods of reducing moisture are economically employed

By C. C. HERMANN

MOISTURE in compressed air is bad medicine for the tools using the air. The water causes lubrication failure due to sufficient water collecting in the oil chambers to float the oil out so that, instead of having oil for a lubricant, there is nothing left but water. The air tool being made with close clearances, in order to insure a high efficiency, wears rapidly and its efficiency drops rapidly.

Some time ago a series of tests were made on air tools under the direction of the writer. The facts disclosed by these tests for air consumption were so astounding that a system of checking has been continued even after measures had been taken to cure the trouble. The data resulting from these checks are tabulated under the following headings: Number of tool, Make, Normal rating C.F.M., Check consumption C.F.M., Speed of tool R.P.M.

Numerous cases encountered have proved that it pays to run periodic checks on the air consumed by air tools. Such checks will also lead the maintenance department to a further investigation into the maintenance cost of air tools and, possibly, means to reduce this cost will be devised.

In most such investigations the results are identical, namely, that moisture carried over by the air and released during the expansion in the air tool produces the main source of the trouble and expense.

Water in the Air

No such thing as perfectly dry air is to be found in the air lines of industrial establishments. Therefore when the shop foreman pounds your desk and demands dry air he means air which will not give his men a shower bath every time they use the air tool. Water in the air is particularly disagreeable in connection with foundry and core room operations. Visualize a man standing before a core making bench, who is required to use a knee vibrator out of which water pours every time he presses his knee against the valve, and the water going down his trouser leg. A very uncomfortable and disagreeable job indeed. And you cannot blame him for kicking to his foreman. Having received the complaint, or better still, before receiving the complaint, go out to the power plant and observe how the air piping, air intake and air discharge lines are maintained. Check them briefly with some of the following requirements for a good compressed air system.

See if the air intake to the compressors is from the outside of the building and preferably on the east or north side of the building so that the coolest possible air is received. Is there a heat source other than natural near the air intake? Are the intakes provided with filters and have the filters been properly maintained and cleaned regularly? See that the air intake pipe is at least 25 per cent in area of the air compressor piston. This latter will not affect the moisture but it will affect compressor capacity. In looking these things over, bear in mind that with 70 deg. F. intake the compressor will require just cubic foot for cubic foot of air on each side of the cylinder. If, however, the outside air is 40 deg. F. and the shop temperature is 70 deg. F., then only 943 cu. ft. of free air at the intake temperature will be required to deliver 1000 cu. ft. of free air at room temperature. This is due to the fact that the air pipes will not cool below the room temperature through which they pass. If the line temperature can be kept up above the outside temperature two things to our advantage would result. There would be a direct saving in volume, cubic feet of air compressed, and there would be less water at the air consuming tools.

Pressure-Temperature-Humidity

When compressing air at a given relative humidity, several things take place. Take for example a relative humidity of 56 per cent and absolute pressure of six atmospheres. If we could keep the temperature of the air during compression constant enough water would be condensed out of the air to reduce its relative humidity to 8 per cent. The temperature, however, rises during compression in spite of the attempt to cool, and for each 20 deg. F. increase in temperature its capacity for moisture doubles. Therefore, regardless of the initial humidity, the humidity of the compressed air, as it leaves the compressor, is far below this figure.

This would be fine if we could hold the temperature up until the air is expanded and out of the air tool, but this we cannot do. The temperature drops as the air travels through the pipe lines leading to the points of consumption and when expanded in the tool it drops considerably below the room temperature therefore the deluge. Well what is the cure?

The best way I have found to cure the trouble is by the installation of aftercoolers on the air lines. Aftercoolers have the capacity to cool the air under compression to a point where sufficient water will be condensed so that commercially dry air is available at the point of consumption. The air will not be perfectly dry, as such is not necessary, and to produce perfectly dry air would be entirely too costly. Just sufficient moisture must be removed to eliminate the condensation at the point of expansion in the air tool or orifice. Usually if the air is cooled to 10 deg. F. below the average room temperature the trouble will disappear.

It does not take much water or very cold water to do a good job. River water can ordinarily be used, however, the colder the water the less will be required. Any handbook on compressed air will provide tables showing the temperature of the out air with a given volume and temperature of water through the after-cooler.

After-coolers, although they get us out of the water difficulty, get us into another difficulty at times. They reduce the capacity of our compressors or the equivalent. Obviously if we reduce the temperature of the air we reduce its volume and it would be preferable to insulate the air pipe lines to conserve the heat in the air in order to hold up our compressed air volume. Well there are two courses open. One is to locate the after-coolers as near the point of compression as possible so as to increase our pipe line c.f.m. capacity and the other is to reheat the air after it has passed through the after-cooler. Of course to reheat the air brings about another increase in cost of compressed air but it can be done in such manner that such cost will be far below the cost of compressor capacity.

1st. The reheating can be done with exhaust steam heat exchangers. The heat exchanger should be placed as close to the point of use as possible so as to prevent radiation and consequent reduction in volume. Following reheating, the pipe line should be covered to near the point of consumption. The covering need not be expensive as the temperatures involved are low.

2nd. Double back with the pipe carrying the outlet or cool air along the pipe carrying the inlet or hot air to the after-cooler so that the one can give up its heat to the other. The after-cooler can then be placed at the end of the loop and some saving effected in the size of the after-cooler as well as a water saving because some of the heat of the air has been extracted. The two pipes should be covered together to assist in the heat exchange.

3rd. Run the cool air pipe through high temperature rooms, over heating furnaces and in other ways make use of waste heat without the installation of heat exchangers. It would not be wise to expend much money in piping to do this without first making a very complete study to see if you can pay back on the return an amount comparable to a heat exchanger.

Cooling the air prior to compression is another suitable way to eliminate the moisture. By this scheme the air is cooled to a point, depending upon its initial humidity and absolute pressure on compression, where the resulting humidity will not exceed 100 per cent or the saturation point. For example, if the relative humidity is 50 per cent and the barometer is 29.92 in. hg. outside temperature 70 deg. F., room temperature 70 deg. F. and the air pressure at the terminal of the line 100 lb. gage, at 70 deg. F. and 50 per cent relative humidity the air contains 54 grains of moisture per lb. The compression ratio is 7.8 so that the humidity at the end of compression, temperature remaining constant, would be 390 per cent. To reduce the humidity to 100 per cent at 70 deg. F. 100 lb., gage pressure the moisture content must be reduced to 5 gr. per lb. of air at the start or 49 gr. of moisture must be removed through the process of condensation. This is accomplished by reducing the air temperature to the necessary low point. Disregarding freezing, this point would be about 5 deg. F., however, it is not necessary to go below freezing temperature to reduce the humidity to the point where condensation is avoided at the air tool.

Diesels Pay Their Way

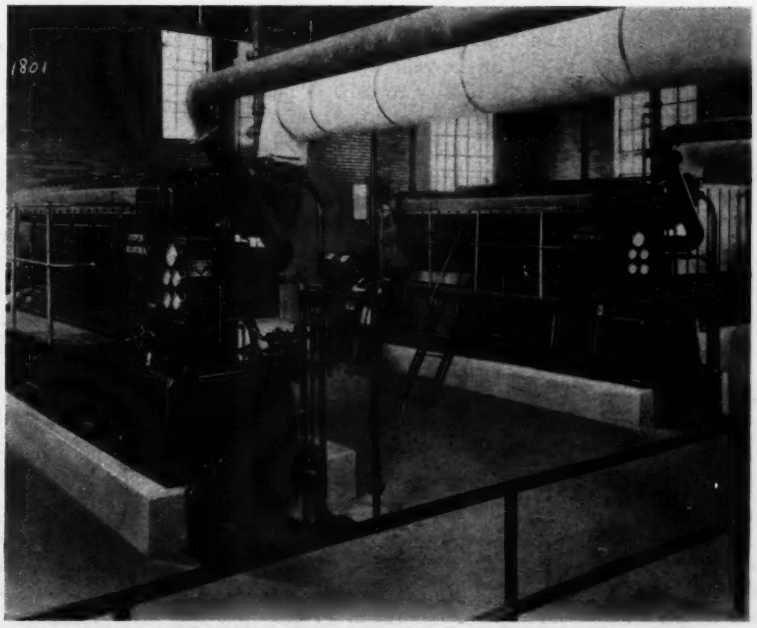
CONNERSVILLE, IND., recently placed its water works on an oil ration and pensioned the old steam driven equipment. Two Cooper-Bessemer Type JT-6 Diesels, each direct connected to a 400 r.p.m., 250 kw. Westinghouse generator, and three motor driven pumps now take care of the water needs of the city at a cost of $14.20 a day or $31.80 a day less than the former cost. The improved service is expected to lead to reduced fire insurance rates throughout the town. Equally important, the city is considering taking over the street lighting now supplied by the local utility.

The entire installation, complete with auxiliaries, was installed by the Cooper-Bessemer Corp. and with the active support of William F. Dentlinger, mayor, has been made into a show place—an example of what may be expected of a modern municipal plant. Practically all auxiliary equipment is located in the basement between the foundations of the engines on the same level as the pump pit.

Engines are equipped with Maxim silencers and American air filters. Exciters are v-belted to the main generator shaft and mounted over an outboard bearing on a special base with a jackscrew for adjusting belt tension.

Cooling water is supplied from a closed system with makeup to the soft water side supplied by a 10 g.p.m. Rainbow softener. A 100 gal. expansion tank with a Viking low water alarm is provided and the water is pumped through the jackets by two Gardner-Denver 1½ in. 125 g.p.m. centrifugal pumps, each driven by 5 hp. motors. Two Gardner-Denver 2 in. pumps driven by 3 hp. motors supply raw water to the Griscom-Russell heat exchangers. The two sets of pumps are interconnected for emergency use on either system.

Fuel oil is stored in two 10 ft. 6 in. by 24 ft. Graver tanks.



Readers' Conference

Trade or Profession

In several of of the recent issues of "Power Plant Engineering" there has been some discussion of the reasons why most engineers do not achieve success in their profession commensurate with their training and experience, and the reasons why engineers as a class do not receive the public recognition which they believe should be their just due. Several attempts have been made to answer these questions, none of which has, I believe, ferreted out the underlying cause or pointed to the true solution of the problem.

The trouble is that most engineers, unconsciously perhaps, regard their work as a skilled trade rather than as a profession. The man with a head crammed full of thermodynamics, and who has all the answers to the successful operation of his company's power plant at his fingertips, is highly incensed at being condemned to the dungeon of the engine room while the board of directors choose a rank outsider to keep the dust off the superintendent's swivel chair. Let us not forget that the engineering colleges of the country turn loose hundreds, perhaps thousands, of young men each year, who know as much, or even more, about the theoretical problems of engineering as many successful engineers who have had many years in which to forget all about Messrs. Bernoulli, Boyle, Stefan, et al. A walking reference book is not necessarily a capable executive.

Nor is high pressure salesmanship the answer. The fellow who can persuade a susceptible housewife that her life would be incomplete without a brush especially designed to clean the blades of an egg-beater will find an entirely different situation when he attempts to convince a group of skeptical executives that a new boiler to replace the old one, which has not yet blown up, will show a profit at the end of the year. Selling is excellent training. It develops the ability to talk to people convincingly and without embarrassment. It offers a valuable course in practical psychology. But rarely will you find a more unbearable boor than the insistent gentleman who can "sell 'em anything and make 'em like it."

I believe that to succeed in engineering a man must be what Dr. Harvey Davis of the Stevens Institute of Technology has aptly termed an "engineer plus"; he should be a cultured professional gentleman rather than merely a highly skilled artisan. A sound training in the fundamentals of engineering and years of practical experience are far from non-essential. I am not attempting to state that anyone can be an engineer without an engineer's education; but I do maintain that these by themselves are not all sufficient. They are merely the foundation upon which a successful career is built. An engineer should have a complete command of English, he should cultivate the ability to handle and to lead men, and he will find that some knowledge of the social sciences and fine arts is far from detrimental.

The ability to speak and to write his mother tongue correctly and forcefully is of utmost importance. All our contact with other people is through either the spoken or written word. It is assumed of course, that all professional engineers are far above the "dese, dem and dose" class, but this signifies nothing. Most of the mechanics and helpers who work under the engineer are beyond that stage today. It is particularly important to use good English in the presence of those who may be under one's supervision. It is surprising to discover how quickly even the lowliest laborer will note the speech of his superior, and his opinion of the "boss's" capability will depend upon this factor as much as, or more than, his ability to direct the work in hand.

The use of good English is equally effective upon one's superiors. A concise, well written letter is bound to stand out if only by contrast with the many poorly written and faulty letters that are dashed off every day. A technical analysis or a business report need not be a dry compilation of facts and statistics. It can be made, with a little thought and care, interesting and alive. A few carefully chosen words, quietly though firmly spoken, will often produce a more favorable impression than all the verbal pyrotechnics and table poundings that have been since the dawn of time.

Next comes leadership, the ability to handle men. The man who plagues the porter or bullies the office boy usually becomes a cringing "yes-man" when confronting his superior. Treat every one as a human being regardless of his position. Few men, especially those who work hard for a living, will stand being patronized or held in contempt. They feel that they have a right to be treated as fellow workers and not as irresponsible children who must be continually led by the hand. Give a man all the responsibility that he can safely handle; show him that you trust him. It is possible to be firm without being tyrannical, fair without being meek. A helpful suggestion is often worth more than a "bawling out", and those two words, "thank you", sincerely spoken, are of inestimable value. It is common knowledge that no man knows everything, and it is no disgrace to admit to not knowing all the answers. It is far better to say "I'll look it up", than to try to bluff out of a difficult question.

On the other hand, few men are worthy objects of worship and awe. Persons in the upper niches of an organization should be treated with the deference and respect due to them, but there is never any reason to fear them or grovel before them. Do your job to the best of your ability regardless of how useless or insignificant it may seem at the moment. A man who cannot handle a little job cannot handle a big one. That fact is so basic as to be almost banal.

Lastly, of what use is a knowledge of the so-called cultural studies? Is the fact that all Gaul was divided into three parts going to bring a recalcitrant feed pump into line? Will an appreciation of Beethoven prevent a boiler from priming? True, such things are no particular assets to an engineer in the performance of his work, but it must be remembered that it is quite

as necessary to make social contacts as it is to make them professionally. An engineer ought to be as much at home in a drawing-room, as he is in a power plant or a laboratory. Few people have even a superficial interest in the more prosaic features of engineering and the engineer must be sufficiently well versed in the subjects of common interest to be intelligent and alert in their discussion. If he can bring his profession into his conversation casually, without dragging it in by the heels and flinging it at people's heads, so much the better. He will become an advocate in the cause of bringing home the fact to people in general that engineering *is* a profession, and not a trade.

Long Island City, N. Y. R. G. P.

Indicator Card Easily Spaced

IN THE SKETCH is shown a diagram which may be of some assistance to engineers who take indicator cards frequently, but are not blessed with possession of a planimeter.

As it will give the locations of ordinates regardless of the length of the card, it may save time.

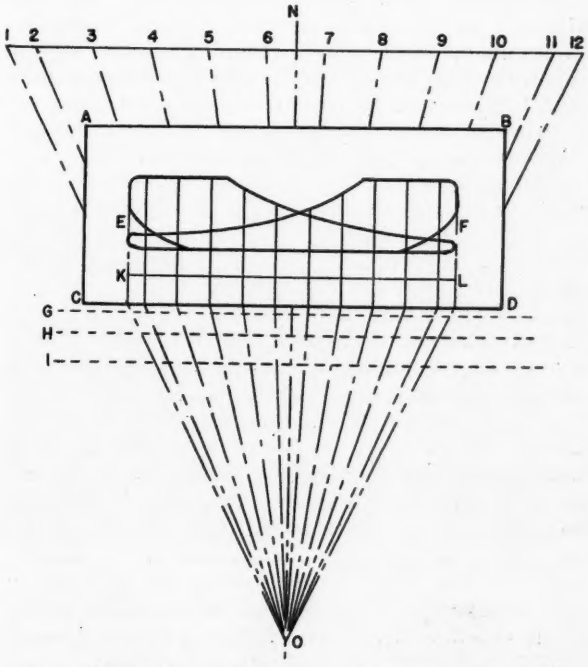


Chart used in calculating area of indicator card

To construct the diagram lay off the required number of points as 1 to 12, on a line of any length, the end spaces 1 to 2 and 11 to 12 being half the length of the intermediate spaces. Draw N-O perpendicular to the line and bisecting it, then draw lines from the points to O, as 1-0, 2-0, etc. Lines G, H, I, are drawn parallel to 1-12 and serve as guide lines for the card.

To use the diagram, perpendiculars E and F are drawn to the atmospheric line KL on the card. The card is then laid on the diagram with the atmospheric line parallel to one of the guide lines, and perpendiculars E and F intersecting radial lines O-1 and O-12 at the edge of the card. Intersections of all radical lines with the exception N-O are then marked off on the edge of the card and perpendiculars erected on the card. These are the ordinates and the card can then be figured in the usual manner.

The guide lines should be drawn in such positions as to coincide closely with the card lengths most frequently met with.

Houston, Tex. H. G. SCHEER.

Old Man River

AFTER ONE has become accustomed to his own plant for many years, knows just how long one firing will go and just how long one half-pint lubricator of oil will last, isn't it the devil's own luck to run up against a knotty problem and find no solution in "The Engineers' Prompt Answer to Any Problem"?

John Doe had a little plant with two 6-ft. boilers and two small engines; one, a single high-pressure, non-condensing unit and the other a tandem compound condensing unit. Both of these machines operated very quietly and efficiently, one furnishing exhaust steam, where needed, and the other power at a low water rate.

John Doe did his own firing, giving all possible attention to the engines, generator and switchboard with the time between firings and other boiler room routine. Not long ago one of the engines developed a slight knocking, kind of a clicking, in the cylinder. This was a new sound to John. It might be a faulty ring, an insecure bolt in the follower or other cause; at any rate, it was a new sound to John Doe.

Opening the drips slightly, it was on the high-pressure, non-condensing unit, relieved the condition temporarily, but the other unit had developed a similar tatoo.

Finally John had to bring the compound machine to a dead stop in order to save it from destruction. Quite naturally the management wanted to know the "whys and wherefores" and John was stumped for the time being. One can't be fireman, electrician and engineer and have time to analyze happenings, all in a minute!

The curious part of the situation was the fact that the first engine to clatter was perfectly o.k. after the other unit had been stopped.

With only one engine in operation the boiler in service had to be fired and John discovered that the water was acting a bit nervous. John was that way himself, by now, to quite some extent. Drawing a pailful of water from the column, John noticed that it was discolored and slippery. Here was something that had never obtained before.

He was making plans to pull the head on the engine that was stopped and see what he could find but suddenly light dawned. He slipped down to the river; it wasn't really a river, only a creek.

Sure enough! The surface was scummed with a combination of ash, oil, cans and various other variety of debris.

The steam had been carrying over slugs of water. The boiler positively had been priming or perhaps foaming. John Doe had never been up against this before but he was no dumbbell. He made a report to the office and the office discovered that a dump fire, some

distance up the creek, had been extinguished by the city firemen who, no doubt, had added their various mixtures of chemicals to the mass and John Doe's boiler had sampled it all.

He started the other boiler on city water and used that source until Old Man River cleared again and now he probably will watch the water in the creek as closely as the water in his gage glasses.

N. Y. City. C. W. PETERS.

Boiler Patches

1. DRAW A SKETCH showing the kind of patch you would put on a H.r.t. boiler, taking in 5 rivets of girth seam?

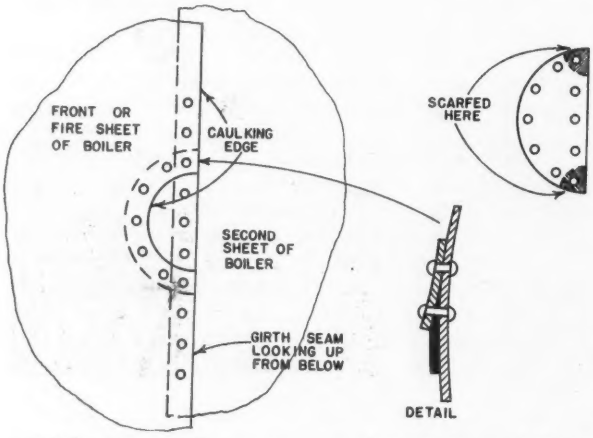
2. Figure the safe working pressure of the patch according to the A. S. M. E. Code?

3. Why is more stress allowed per sq. in. on stays over a certain size than is allowed per sq. in. on stays under this size?

Chicopee, Mass. E. P.

These questions were answered as follows by C. C. Custer:

1. This question is somewhat indefinite because the size of the hole is not mentioned. As it includes only 5 rivets of the girth seam, I assume it is necessary to do away with some bad fire cracks and I would put on a D-patch as shown by the sketch. Being small, this patch would not affect the safe working pressure of the boiler as determined by the longitudinal joint.



Details of patch. The corners are scarfed and the patch fitted between the two sheets. It should be put on inside the boiler and overlap the second sheet.

2. Calculations are somewhat involved but not difficult and will be explained in an article to be published soon in Power Plant Engineering.

3. Allowable stress on stays depends upon the type and location as well as on size and allowable values are listed in a table in the A. S. M. E. Code. Short stays are not allowed so much tensile strength in figuring as the longer stays because they have other stresses than a straight pull on them. Fire-box stays are subject to the unequal expansion and contraction of the furnace lining and the outside sheet which occasionally causes a stay to break off at or near the outside sheet. To obviate this a type of flexible stay is often used in locomotive work. The type of stays used in staying L. F. B. furnaces is of a softer grade of metal with an allowed strength of 7500 lb. per sq. in. Hollow steel staybolts are given an allowance of 8000 lb. per sq. in. The next classification refers to the 1¼-in. Scully Stays used as angle braces to stay the heads and these are allowed 9500 lb. per sq. in. Steel through stays used to stay the lower segment of a H.r.t. boiler are allowed 10,400 lb. per sq. in. These are longer stays that have no side strains on them. Some of these rules may be slightly empirical.

A recent communication from the Division of Inspection, Department of Public Safety, Commonwealth of Massachusetts, states:

"Previous to the adoption of the rules by Massachusetts, all of the best engineering authorities required a larger factor of safety on small braces than they did on the larger ones, and at the present time the A. S. M. E. requires the same.

"This is to compensate for the effect of corrosion and deterioration on the small braces."

Economical Methods of Blowing Down Boilers

REFERRING to the interesting article by Charles L. Hubbard in the August number of Power Plant Engineering, pages 494 and 495, there is one method that Mr. Hubbard does not mention. In fact it is a method that I have never seen mentioned in any article and that is—the method of continuous blow-down through a modern type boiler feedwater regulator.

The regulator that I have in mind operates from the water column of the boiler where the water is comparatively quiescent, and consequently where concentration is likely to be higher than elsewhere in the boiler. This regulator depends upon continuous blow-down for its successful operation. It combines in a unique and economical manner the advantages of continuous blow-down with the advantages of continuous scientific regulation of water level.

Tests were recently conducted by The New York Testing Laboratories comparing water going into a boiler with the water continuously discharged through the boiler feed regulator. Their report, verbatim, was as follows:

	Ingoing Water		Discharge Water	
	Grams Per Liter	Grains Per Gallon	Grams Per Liter	Grams Per Gal.
Total Solids	0.1300	7.60	1.0840	63.36
Loss on Ignition—				
Organic Matter	0.0360	2.10	0.3200	18.70
Silica	0.0160	0.94	0.0600	3.51
Iron Oxide	0.0140	0.82	0.0220	1.29
Calcium Oxide	0.0060	0.35	0.0840	4.91
Magnesium Oxide	0.0036	0.21	0.0108	0.63
Sodium Oxide	0.0037	0.22	0.1846	10.79
Chlorides	0.0100	0.58	0.1257	7.35
Sulphates	0.0150	0.88	0.2140	12.51
Phosphates	0.0020	0.12	0.0165	0.96
Carbonates	0.0237	1.38	0.0464	2.71

We find from these analyses that the discharge water contains 8.3 times the concentration of the ingoing water injected into the boiler.

Inasmuch as the discharge water passes through orifices in the regulating element—orifices that to the eye may be regarded as "small"—usage of this type of regulator over a period of several years in many boilers all over the United States has demonstrated

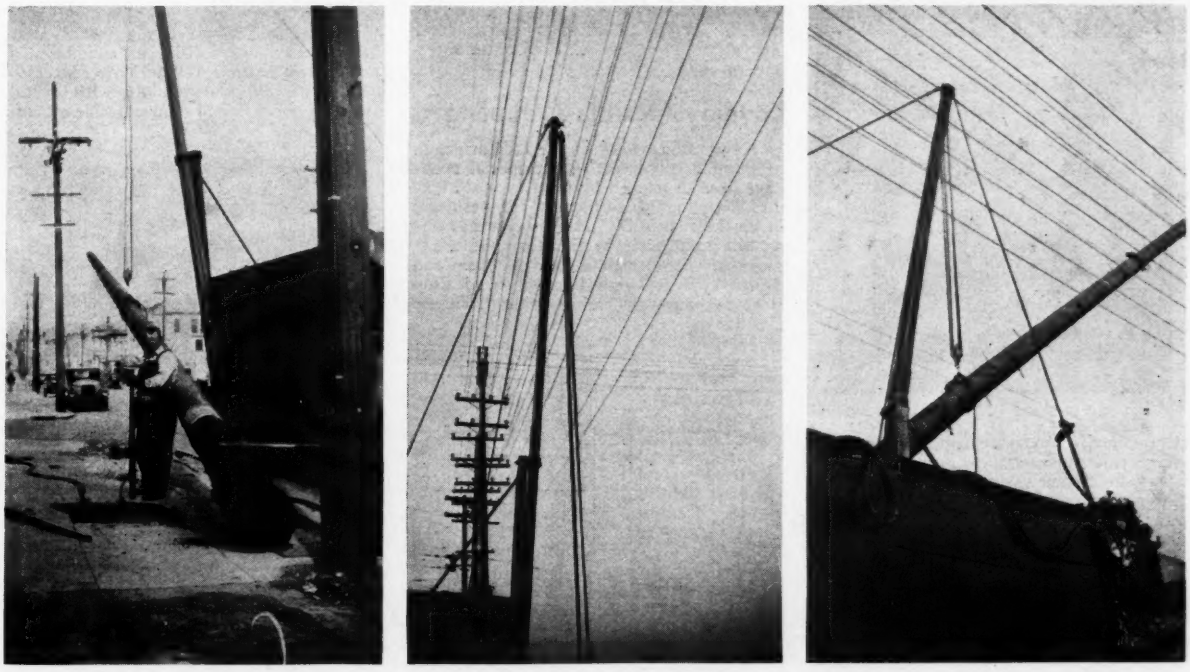
that the method of regulation is entirely reliable. There has not yet been one case of serious stoppage due to clogging. In fact, if serious clogging should develop that would be proof of very bad water. Besides, where it is desired to step up the quantity of discharge, that can be done by increasing the orifice diameter in proper ratio to each other.

By returning the blowoff to a heat interchanger, as is commonly done with other arrangements of continuous blowoff, the heat in the blowoff water from the regulator is utilized.

Newark, N. J. W. F. SCHAPHORST.

Portable Gin Pole

THESE THREE pictures show a new portable gin pole devised by G. Leister, a Pacific Gas and Electric Co. foreman. This pole is designed to be attached to a line truck and is capable of handling poles up to 105 ft. in height and weighing as much as 4½ tons.



Three views of truck-mounted gin pole as used for setting pole

It is made of select wood and properly treated with linseed oil. Being mounted on the side of the truck, it is in keeping with the lines of traffic at all times. It can be extended upward to d. c. feeders and secondaries and in various cases extending to 4100 v. primaries, not endangering the company's lines, or other company lines, such as fire alarm, police alarm, or telephone cables.

The fact that the derrick is mounted on the side of the truck, makes it possible to drive straight in line with traffic and pick up a pole and raise it to the required position and carry it to the hole and lower it. This has many advantages over the usual iron derrick mounted at the center of the truck. Such an arrangement will not enable you to raise the pole and drive 50 or 100 ft. without interfering with wires. Because of the derrick being mounted at the center of the truck, the pole would be 7 ft. or more to the side of the center of lead wires, making it impossible to comply with the safety laws.

The portable gin pole is so arranged that aerial taps may be worked on by merely raising the derrick to the desired position and a man may climb the structure which takes the place of a ladder or boatswain chair which would otherwise be necessary.

The foot of the derrick rests upon the ground, which relieves the vehicle of the load placed upon the gin pole. The derrick is capable of being set up or taken down and transported from point to point with extremely little effort.

San Francisco, Cal. C. W. GEIGER.

Rapid Cooling of Boiler

OUR PLANT, like many others, has only one boiler capable of supplying the steam during plant process work. The internal cleaning and inspecting must be done usually on Sundays when loads are light. Our problem was to cool the boiler sufficiently so that men could work in it the same day it was opened and the inspector could make a thorough internal inspection. To accomplish this I have arranged an air duct 14 in. by 24 in. by 7 ft. long with two elliptical extensions about 24 in. long and perpendicular to the ends of the duct. These elliptical ends are of two sizes. One fits into the mud drum manhole and the other into the nearest manhole in the furnace setting. (Ours is a Stirling boiler but a similar arrangement could be made on any multidrum boiler.) All other holes into the boiler and furnace are left closed excepting the drum to be entered. Furnace dampers are turned wide open. This draws a large volume of room air into the drum where men are working. The induced draft fan can also be used to give additional air flow. We can do the internal work without any delays.

West Fargo, N. D. GEORGE SUCHY.

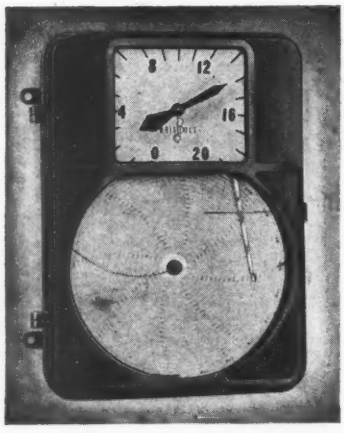
New Equipment

If you wish further information about any of the equipment described, it will be gladly furnished without obligation. Write POWER PLANT ENGINEERING.

Potentiometer Pyrometer

FOR RECORDING and indicating thermocouple temperatures a new potentiometer pyrometer has been recently developed by The Bristol Co., Waterbury, Conn.

This new indicating recording Pyromaster, provides for direct marking on a 12-inch round-chart and scale indication on a large dial. It employs the potentiometer method of measurement, using standard thermocouples and extension leads, but it operates on a new and simplified principle.



Operating mechanism is simple and compact; the pen arm or indicator is actuated through the relay switches in small steps, at a rate depending upon the rate of change in temperature at the thermocouple; no lubrication is required; the cold-junction compensator is fully automatic and it is housed in a standard Bristol case.

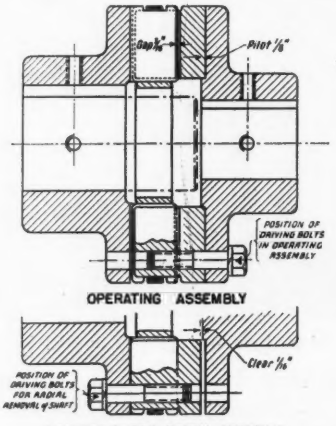
The Pyromaster is available as a recorder, indicator, recorder with indicating scale, recorder controller, and as a recorder controller with indicating scale. Controllers are of either the pneumatic of electric type.

Diesel Compressors

DIESEL ENGINE DRIVEN compressors of a new design for both portable and stationary service have been announced by the Chicago Pneumatic Tool Co., 6 East 44th St., New York City. The portable compressors have a capacity of 700 c.f.m. against a normal discharge pressure of 100 lb. per sq. in. and consists of a CP Type 48 vertical, four cylinder, four cycle, medium speed Diesel engine on a common crankshaft with a V type two stage, double-acting, water-cooled compressor. The stationary unit is made in two sizes with three or four engine cylinders rated at 112 and 150 hp. respectively and with two-stage compressor cylinders with displacements of 655 and 830 c.f.m. respectively. The engine of the stationary unit is started by compressed air and gasoline engine-driven air-starting equipment is included. The portable units are mounted on rubber tired wheels; the stationary unit on skids.

Lovejoy Flexible Coupling

NEW ADAPTATIONS of the L-R principle of flexible coupling to meet special needs have been developed by the Lovejoy Flexible Coupling Co., Chicago, Ill., resulting in the L-R Type WQ. This type has one set of jaws made in the form of a removable ring, which is held in place and driven by 3, 5, 7 or 9 hexagon head alloy steel cap screws which operate from the jaw body.


Gap 3/16"
Pilot 1/16"
POSITION OF DRIVING BOLTS IN OPERATING ASSEMBLY
OPERATING ASSEMBLY
Clear 1/16"
POSITION OF DRIVING BOLTS FOR RADIAL REMOVAL OF SHAFT
ASSEMBLY FOR RADIAL REMOVAL OF CONNECTED SHAFTS

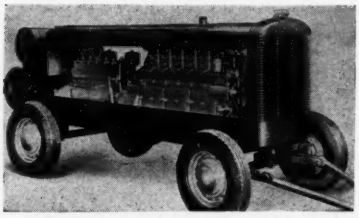
As the pilot which holds the jaw ring in place is 1/8 in. deep, while the gap between the cushions and the jaw body is 3/16 in., when the removable jaw ring is pulled over there develops a clearance of 1/16 in. which is ample for rotating either half of the coupling. This independent rotation is most valuable on such jobs as gasoline, steam, and Diesel engines, where it is necessary to set or time the engine, which, of course, cannot be done with the machinery connected.

An important feature of this new coupling is that this disconnecting is secured without moving the load cushions or steel retaining ban; the only work being necessary is to take out the cap screws and reverse them so that they operate from the other body.

Three types of cushions are used. Metalflex—a high grade, long wearing brake lining material, used where heavy shock loads develop. Leather load cushions, of best quality oak-tanned belting leather, for use on sustained loads and greater misalinement. Multiflex cushions, a rubber duck fabric vulcanized under pressure, employed where loads fluctuate considerably and maximum resiliency is important.

Diesel-Powered Air Compressor

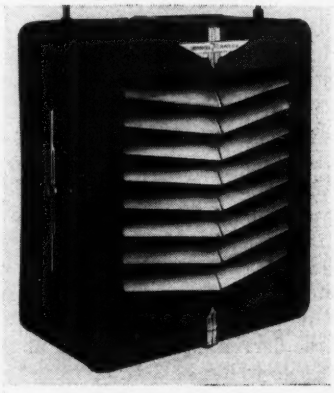
FAIRBANKS, MORSE & Co., 900 S. Wabash Ave., Chicago, Ill., has announced a new self-contained, Diesel-powered, 210-c.f.m. air compressor, available with several types of portable and semi-portable mountings, for a wide range of service applications. This new compressor combines the F-M Model 36-A Diesel with an air compressor, making available a compact, light-weight unit. The compressor is designed to operate at full engine speed, permitting direct-connection to the engine without reduction gears or belts and without sacrificing engine horsepower through reducing the rated speed.



The new Fairbanks-Morse Diesel-powered air compressor is available with several types of mounting: wooden skid, steel wheel, solid or pneumatic rubber tired wheel, four- or two-wheeled trailer, and motor or railway truck.

De Luxe Type Unit Heater

ANNOUNCEMENT of the development of the Thermolier De Luxe Type unit heater by Grinnell Co., Inc., Providence, R. I.,



for installations where appearance is a major factor.

Thermolier De Luxe Type embodies the heating unit of the company's industrial and factory types, in a modern housing finished in crackle black and satin chrome. Heat distribution has also been improved by new angular louvres which provide widespread heat flow. Inlet and outlet pipes have been relocated at the rear and the specially-designed motor and fan are concealed.

The new unit heater is recommended for installation in stores, shops, offices, lobbies and similar places where a handsome, efficient source of heat is required.

Pyro Bi-Optical Pyrometer

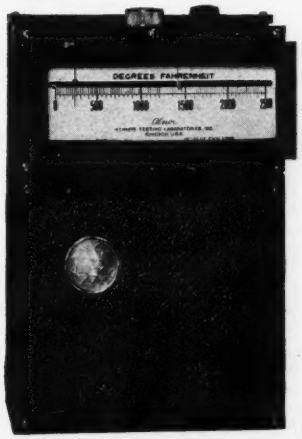
DEVELOPED by The Pyrometer Instrument Co., 103 Lafayette St., New York, N. Y., into a convenient and handy self-contained instrument for practical purposes, new Pyro Bi-Optical pyrometer is based on the use of light filters and color wedges which are transparent to a number of colors simultaneously. By using filters with a number of transparencies both for separation and for mixing and toning down, any complicated optical or mechanical device for the production or combination of colors is rendered superfluous and the creation of a surprisingly simple temperature measuring device in the form of colored discs is rendered possible.

With this new instrument the temperature of the black body and the actual temperature may be ascertained simultaneously. The instrument is furnished with scale ranges from about 900-1900 deg. C. or 1700-3500 deg. F. and may be used for innumerable laboratory and research applications including incandescent iron and iron alloys in the open and flame heated furnaces.

Pyrometer Controller

FOR THOSE who desire to automatically control temperatures of heat treating furnaces, melting pots or other heating devices at a definite pre-determined point. The "Alnor" Pyrometer Controller is offered by the Illinois Testing Laboratories, Inc., 420 N. La Salle St., Chicago, Ill. The principle of operation is electronic similar to a radio circuit. The pointer of the indicating pyrometer carries a small vane. An adjustable target is provided which carries two condenser plates or vanes. These vanes are the capacitive element of a tuned circuit.

Except at the point when the temperature indicating pointer and the target coincides the circuit is unchanged. When the temperature pointer with its vane approaches the temperature setting, the vanes of the pointer and target interleave and produce a circuit change which in turn operates a relay. The heating current, if electric, is shutoff, or, in case of the fuel fired operation, the fuel valve is closed



partially or completely, depending on the type of valve used.

There is neither motor nor depressor bar used in the Alnor Controller nor is there any direct contact between the vanes. The temperature indicating pointer is free to give continuous indication and control. A red bull's-eye indicates whether the heat in the furnace is on or off.

For electric furnace operation, metallic mercury switches are provided. These are strong, durable and practically non-breakable. Positive make and break contact is obtained in an interval of as little as 3½-deg. tilt. Mercury tubes are available in sizes up to 35 amp. at 110 v. a.c. For higher amperages a separate circuit breaker is necessary. For fuel fired applications, a suitable valve must be used which can be either of the solinoid or motorized type as desired or necessary for the requirement.

The Pyrometer Indicator of the Alnor Controller is the well known and extensively used Type 2860 Horizontal Edgewise. The case of the Pyrometer is weather-proof, fume proof, and dust tight. Standard temperature ranges 0-300, 0-400, 0-500, 0-600, 0-800, 0-1000, 0-1200, 0-1600, 0-2000, 0-2500, 0-3000 deg. Fahrenheit or Centigrade equivalent can be calibrated and furnished for iron-constantan, chromel constantan, chromel-alumel, platinum-platinum 10 or 13 per cent rhodium depending on equipment and range.

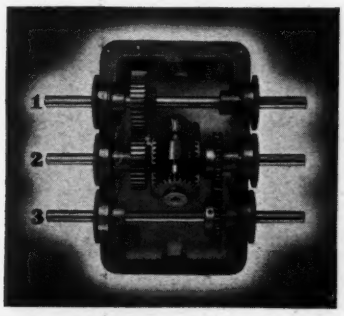
Reeves Differential

A NEW DIFFERENTIAL developed by Reeves Pulley Co., Columbus, Ind., and known as model MDB-3, is similar in principle to the differential in a motor car, and is used for a variety of requirements in automatic speed control, such as synchronization of two or more machines or parts of a single machine, and maintenance of uniform peripheral winding or unwinding speeds.

Within a unit housing are mounted three parallel shafts operating in a bath of oil. Gears of 1:1 ratio drive between shaft 1 and the differential gearing. Between shaft 3 and the differential gearing is 1:1 chain drive. Special ratios, however, are also available.

For automatic control service, shafts 1 and 3 are connected to the driven machine or machines. Shaft 2 is connected to the speed changing screw of the Reeves Transmission. When shafts 1 and 3 are driven in the same direction at the same speed, shaft 2 stands still. When the speed of the driven machine varies above or below desired speed, this variation is transmitted to shaft 2 which speeds up or slows down the transmission until synchronous speed is restored.

The differential may also be used as primary driving equipment for loads not exceeding its rated torque and speed capacity. For example, it may be used with other equipment to control index or reg-



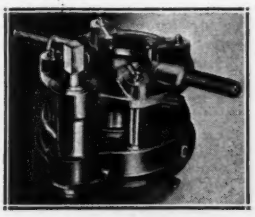
ister, either manually or with photo-electric equipment.

Infinite range of speed variation is possible by connecting shafts 1 and 3 to the constant and variable speed shafts, respectively, of the transmission. By turning the speed control hand-wheel on the transmission, shaft 2 may be adjusted to any speed in either direction, including zero r.p.m.

Overall dimensions of the unit are 8 in. wide, 11 in. long and 6⅝ in. high. Shafts are extended on both sides so installation may be made as desired.

Beaver 48-R Pipe Threader

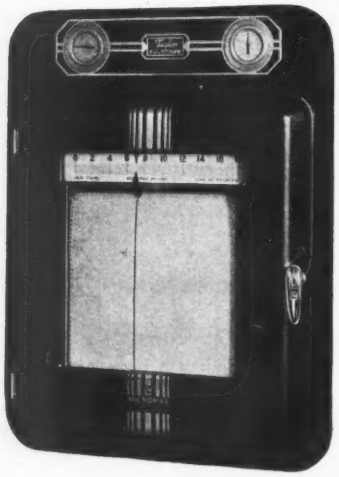
FIVE IMPORTANT mechanical improvements are embodied in the design of the new Beaver 48-R pipe threader now manufactured by Beaver Pipe Tools, Inc., Warren, O. This tool is of the semi-adjustable taper-post type, using a separate set of dies for each size suitable for use on 2½ to 4-in. pipe.



Design features of special interest are: 1. An extra wide die, with a wide throat to center and hold the tool on the pipe. 2. The gears are fully-inclosed so that chips and dirt cannot get in them. 3. The driving pinion is straddle-mounted, with a bearing both above and below the gear teeth on the pinion. 4. Dies are held in position by a fully inclosed, spring-backed ball. 5. The proper position for setting dies to cut a standard thread is marked on a shoulder on the tapered post.

Taylor Fulscope Micromax Controller

THE FULSCOPE MICROMAX Air-operated Potentiometer Controller, recently placed on the market by the Taylor Instrument Companies, Rochester, N. Y., was designed for process control problems where smooth, proportional valve action is imperative.



It utilizes the same completely adjustable, air-operated control mechanism that is used in the thousands of Fulscope temperature, pressure, rate of flow, and liquid level controllers now in service.

The temperature measuring system is the Micromax recording and indicating potentiometer in which all functions affecting accuracy of temperature measurement are fully automatic—automatic reference-injunction compensation; automatic, positive balancing of the potentiometer circuit; and automatic current standardization.

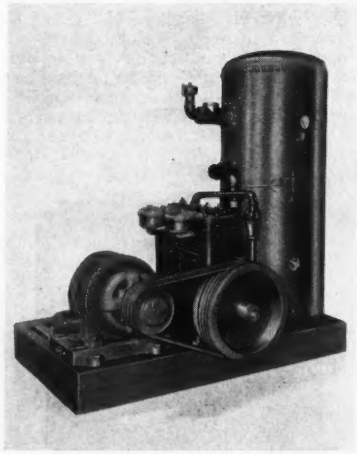
The principal parts of both mechanisms are interchangeable with the many Fulscope and Micromax instruments now in service.

The Fulscope Control Unit operates in conjunction with the Taylor Motosteel Diaphragm Valve. Where precision valve action, or both precision valve action and compensation for changes in load, may be necessary to prevent deviation from the control point, the Fulscope control mechanism can be supplemented with the Taylor Valv-Precisor or Dubl-Response Control Unit, respectively. Thus, control equipment which most economically solves the individual control problem may be selected.

Air Compressors

UTILITY stationary compressors for belt drive are now offered by Schramm Inc., West Chester, Pa., in a complete line of sizes including 120, 150, 230, 300, 380, 450 and 600 cu. ft. compressors.

Outstanding features of the complete assembly include, compact dimensions because of the modern, straightline compressor design, together with short vee belt drive and vertical air receiver. These elements have been carefully engineered into a complete air plant, mounted on a single frame base to occupy minimum space in the plant, the base supplied serving as the compressor's own foundation.



Another economy is introduced by the adaption of 1800 r.p.m. motors for driving. All sizes are adaptable to installations with or without motor or air receiver and offered for belt drive or the new built-in direct motor drive. The compressor unit itself includes such features as force-feed lubrication, mechanically operated intake valve, discharge valve occupying fullhead area, smaller, lighter moving parts and thorough cooling by water.

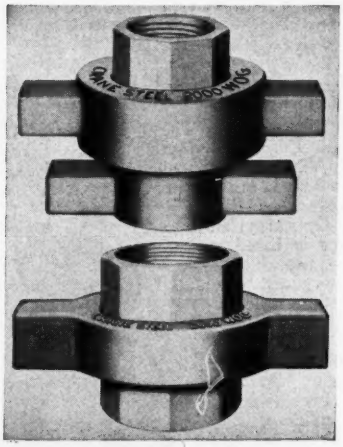
Liquid Transport

FOR AUTOMATICALLY transporting liquids by means of the displacement principle, the Morehead Direct Pressure Liquivator, has just been announced by the Morehead Mfg. Co., Detroit, Mich. The unit consists of a stationary pressure tank to which an operating valve mechanism is externally connected. Counter-weighted displacement tanks within the pressure tank provide the power for valve control through simple but effective leverage.

Since the valve mechanism is separate from the tank, it may be assembled with any sized tank for handling any given volume of liquid while the remote control feature of the operating valves permits a variety of applications for special handling problems. Morehead Liquivators are available in both metering and non-metering types. Either type can be furnished in a self-contained or a remote control assembly to meet individual requirements. The metering units are dependable within 2 per cent plus or minus.

Forged Steel Unions

CRANE Co. has added a new line of hammer lug unions to its products. These unions comprise (1) forged steel screwed unions with one set of lugs, and (2) forged steel screwed unions with two sets of lugs.



Both of these unions have been designed for use in piping systems requiring frequent, or quick, dismantling, either to save time on the job, or for emergency purposes. In either case, a blow with a hammer upon the lug will immediately break the joint without using a wrench.

Hammer lug unions are especially recommended for service on hydraulic roll balancing systems in steel mills, where it is often necessary to break a union connection quickly. The lugs add to the convenience in breaking a joint in cramped spaces where there is not sufficient clearance for a wrench.

The single lug union is made with forged steel tailpieces and thread pieces in sizes 2, 2½, 3 and 4-in. (these parts are of cast steel on the 4-in. size) and have lugs on the union ring. The double lug union is all forged steel, having lugs on both the union ring and the thread-piece. It is made in sizes ⅜, ½ and ¾-in.

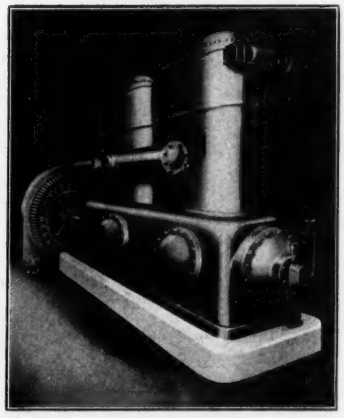
New Building Material

INTRODUCTION, by the Keasbey & Mattison Co., Ambler, Pa., of an entirely new building material for siding and partitions in industrial buildings is a distinct contribution to advancement in building construction. The new material, Trafford Tile, is a composition of asbestos fiber and Portland cement and is particularly suitable for application to large areas where, with the low initial cost of material and application, substantial economies may be effected in the building of skeleton frame buildings such as storehouses, lumber mills, power plants and exposition units.

Trafford Tile is a relatively strong, tough sheet, of fire and weather resistant qualities. It is of natural color in a pleasing gray and requires no protective coating. With its inherent strength, the tile is of exceptionally long life and becomes tougher and stronger with age under normal atmospheric conditions. Its corrugations increase strength and facilitate alinement in application.

New Ammonia Compressor

HIGH-SPEED, multiple-cylinder ammonia compressor, developed to meet the increasing requirements of small floor space and low head room in applications of 100 t. refrigeration capacity and up is announced

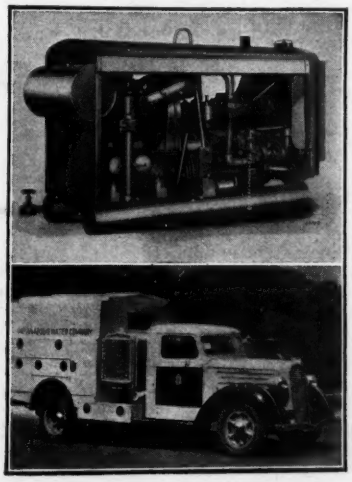


by the York Ice Machinery Corp. Horsepower required per ton of refrigeration is stated as low; features of the compressor are light-weight valves, pressure lubrication throughout, and general design improvements, with higher rotative speeds. The compressor will be built in sizes to furnish from 100 to 800 tons of refrigeration. Although designed for synchronous motor drive, the machine may also be adapted for operation with any type of prime mover.

Diesel-Drive Compressor

COMPACT and self-contained a new utility compressor unit Model U-85 for mounting on a motor truck is announced by Ingersoll-Rand Co., Phillipsburg, N. J. It operates independently of the truck motor and transmission is usually placed crosswise of the truck body so that it takes up but the minimum amount of loading space. Its dimensions are 6 ft. 7 in. x 2 ft. 3½ in., yet it will operate two I-R paving breakers, or one I-R 45 pound Jackhamer and one I-R paving breaker.

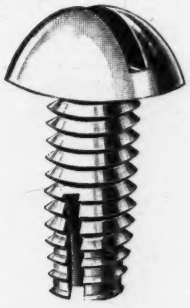
Compactness of the unit allows the truck



to be used for the transportation of tools, men, and the other equipment required for maintenance work. The unit weighs but 2100 lb. and is equipped with a lifting bale so that it can easily be lifted off the truck and put in operation on the ground or from one truck to another should this be necessary.

Thread Cutting Screw

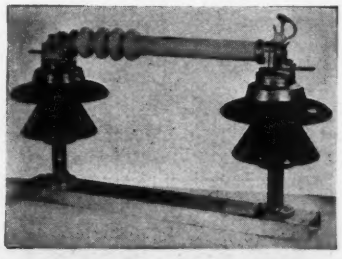
SCREWS designed to cut their own way into plastic material, wood or iron and with the grooves acting to hold them in



place are offered by Shakeproof Lock Washer Co. of Chicago, Ill., in forms and sizes to serve practically any purpose for which machine screws are used. A drilled or bored hole of size necessary to take the body of the main part of the screw is necessary, but no tapping is needed.

New De-ion Power Fuse

FOR SERVICE in medium capacity generating stations and sub-stations of all types, where the short circuit capacity does not exceed 600,000-3 phase kv-a, a new 34.5 kv., 200 amp. disconnecting type BA "De-ion" power fuse is announced by the Westinghouse Electric & Mfg. Co. This light weight fuse can readily be lowered to the ground for inspection or refilling. The complete operation of removing the fuse from service, refilling, and restoring service, can be accomplished in less than one minute's time, which is of initial importance in cutting down outage time and loss of revenue.

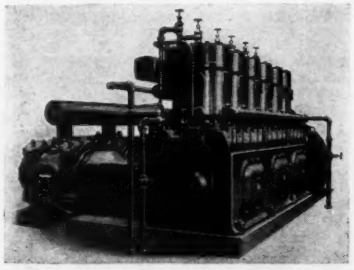


The fuse is hinged at the lower contact to open approximately 75 deg., for use as a disconnecting switch that can be operated by a standard hookstick. Magnetizing currents of a 750 kv-a., three phase transformer are easily interrupted, using this fuse as a disconnect.

As with previously developed "De-ion" fuses, only inexpensive refills need be stocked for replacement. Even this has been greatly simplified, by packing every refill with an individual refilling tool, and simple pictorial instructions in a clearly labeled, moisture proof metal container.

Gas Engine Compressors

TO MEET the demand for a medium size, self-powered, simple and compact air and gas compressor unit applicable to the needs of refineries and natural gasoline plants, gas transportation lines, gas or air-lift pumping, refrigeration and general compressor services, a modern line of four-cycle angle-type



gas engine compressors has been developed by Worthington Pump & Mach. Corp., Harrison, N. J. Combining ruggedness and portability, these Type LCE units occupy little space and, although designed for permanent heavy-duty work, are adaptable for locations which may not be permanent.

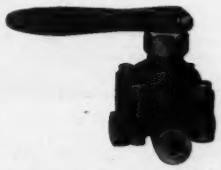
They are built with one to four compressor cylinders, corresponding to 75 to 300 hp.; all compressor cylinders are horizontal and at right angles to the power cylinders. Compressor cylinders are of the standard Worthington design and are fitted throughout with Feather Valves. The engine is a vertical, four-cycle type, with power cylinders, valves and working parts small in comparison with the slower speed horizontal type of similar horsepower. Regardless of engine-compressor size, most parts are interchangeable. All running gear is totally enclosed, making the unit entirely dirt-proof and dust-proof.

These units are shipped in one piece and can be installed easily, quickly and at little expense. It is necessary only to skid them over the bolts, level and grout them.

Nicholson Air Valve

RECENT addition to the several lines of control valves, made by W. H. Nicholson and Co., 214 Oregon St., Wilkes-Barre, Pa., for all pressures and mediums is the model illustrated, designated Style J, a low-priced valve in three and four way types, for operating single and double-acting cylinders utilizing air or oil on pressures to 125 lb.

It is made in ¼, ⅜, ½ and ¾ in. sizes, of flat disc, protected seat design, with bodies and seats of semi-steel, discs of bronze. Port areas are equivalent to full area of pipe sizes they accommodate, and

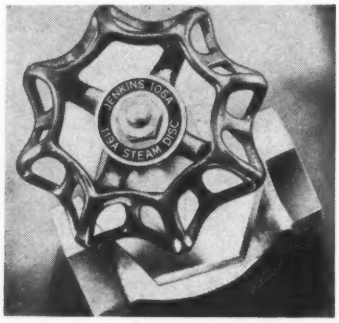


port design permits throttling or full opening, as required. All pipes are 90 deg. apart and lead from valve base horizontally. Valves can be disassembled for inspection without breaking pipe connections.

Operating levers require 90 deg. travel for complete cycle and may be easily adjusted radially on the valve stem to suit convenience of operator.

Jenkins Improved Valves

THREE NEW developments have added convenience and better service to standard bronze valves manufactured by Jenkins Bros., 80 White St., New York. A new handwheel design affords unusually large gripping area without bulkiness and because of its deeply depressed center will prevent the hand from touching a hot wheel nut.

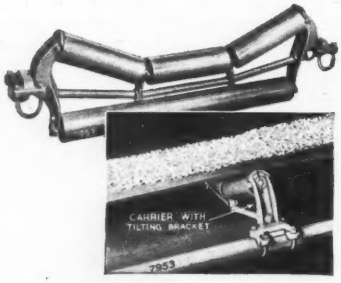


A new valve index plate, held in the depressed center of the wheel by the wheel nut, gives the figure numbers of the valve and the disc number and service to aid in ordering replacements.

A new renewable composition disc is also offered with the statement that it has long life in steam service. Designated No. 119-A, this disc replaces disc No. 119.

New Belt Conveyor Carrier

THIS DESIGN for pipe frame mounting, announced by the Stephens-Adamson Mfg. Co. of Aurora, Ill., is of lightweight, with a rigid truss type frame supported on two parallel pipes to which the carrier brackets are clamped. The frame can be quickly assembled from materials available in the plant and the clamp arrangement permits of shifting locations as may be desired, the rocker type mounting allowing tilting in either direction with travel of the belt.



Rollers turn freely on Fafnir ball bearings which are permanently sealed and lubricated. Outer rolls are inclined to give 20 deg. to the sides of the belt gaining maximum capacity and long belt life. The mounting keeps the belt centered while traveling in either direction, without necessity of guide rollers. The frame of standard 2-in. pipe gives great rigidity and arrangement is in two styles, one the carrier only, the second style including carrier and return roller in one mounting.

Cutler-Hammer, Inc., Appoints New Representatives

FOR ITS DETROIT, Mich., office at 2755 East Grand Blvd., Cutler-Hammer, Inc., has appointed Elmer F. Weiss as manager to succeed A. R. Johnson who becomes manager of the company's Merchandising Sales Division. Mr. Weiss, who is a member of the Assoc. of Iron and Steel Engineers and expert on control equipment for the steel industry, has been with the company since graduation from Carnegie Inst. of Technology in 1922, in the engineering department, in the Chicago sales office and in Detroit territory.

Elmer F. Weiss

At Indianapolis, Ind., E. T. Rees will be manager of the office at 307 North Pennsylvania Ave. His 25 yr. experience in electrical equipment sales and 5 yr. association with the company qualifies him thoroughly to give assistance to customers in solving their problems.

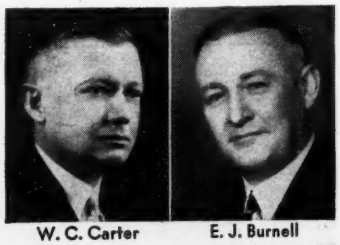
To give service in the Northwest, the company has opened a branch office at 625 N.W. Everett St., Portland, Ore., with F. J. Woldrich in charge. After graduation from the Northwestern School of Commerce and the Univ. of Oregon, Mr. Woldrich became associated with a firm manufacturing motors until 1933 when he joined the Cutler-Hammer sales staff. Long residence in Portland and experience with motors and motor controls have given him knowledge of the industries of the district and their needs, which will enable him to be especially helpful to users of electrical equipment in his territory.

E. T. Rees

F. J. Woldrich

New Vice Presidents of Link-Belt Co.

ALFRED KAUFFMANN, president, Link-Belt Co., announces that at the quarterly meeting of the board of directors, held in Chicago, William C. Carter and Edward J. Burnell were elected vice presidents. Mr. Carter, a mechanical engineering graduate of the University of Illinois, joined the Link-Belt Pershing Road plant organization in 1902 as a draftsman, has consecutively held the positions of engineering department supervisor, construction superintendent, plant superintendent, plant general manager, and in recent years has been in charge of company production, with headquarters in Chicago. Mr. Burnell, a mechanical engineer, from Lehigh University, joined the Link-Belt Philadelphia plant organization in 1913 as a draftsman, has consecutively held the positions of salesman at the company's Pittsburgh office, district sales manager at Boston, district sales manager at Pittsburgh, general sales manager of western division territory with headquarters at the Pershing Road Chicago plant, and more recently has been general manager of this plant.



W. C. Carter E. J. Burnell

News from the Field

RECEIPT OF an order from the Public Service Co. of Colorado for a complete combustion control on a new B. & W. Pulverized coal-fired boiler, and a manual combustion control for an existing boiler at the same station was recently announced by E. W. Wagenseil, general sales manager of the Hagan Corp., Pittsburgh, Pa.

ELECTROLYTIC Metal Protection, Inc., of New York has appointed, D. H. Skeen & Co., 1 La Salle St., Chicago, as its representative for the Chicago district on the Kirkaldy system for protection against corrosion or deposits of scale and slime.

APPALACHIAN COALS, INC., will hold a symposium, the afternoon and evening of Nov. 3 at Columbia Hotel, Kalamazoo, Mich., at which its engineers and coal technologists will lead discussions on, Factors in the Purchase of Coal, Coals for Underfeed Stokers, Pulverized Coal, and Segregation of Coal in Bunkers. Among those taking part in papers and discussion will be T. W. Harris, Jr. of E. I. du Pont de Nemours & Co., Inc., A. W. Thorson of Detroit Edison Co., R. M. Hardgrove of Babcock & Wilcox Co., L. A. Shipman of Southern Coal & Coke Co. The meeting, arranged by J. E. Tobey of Appalachian Coals, Inc., is sponsored by National Association of Power Engineers, Kalamazoo Valley Chief Engineers' Club and Kalamazoo Association of Purchasing Agents.

ROBERT E. DILLON, long identified with the Prime Movers Committee of the Edison Electric Institute, and the Power Generation Committee of the Association of Edison Illuminating Companies, has been appointed vice president in charge of production and engineering for the Edison Electric Illuminating Co. of Boston, Mass. He entered the employ of that organization in 1911, shortly after graduating from Massachusetts Institute of Technology. After two years in the standardizing and testing laboratory he was transferred to the generating department and in 1925 was appointed superintendent.

THE BABCOCK & WILCOX TUBE CO., Beaver Falls, Pa., announces the appointment of Edward D. Emerson as New York Manager of Domestic and Export Sales. Mr. Emerson was formerly with Jones and Laughlin Steel Corp. and Air Reduction Sales Co. The company has also announced the transfer of Bruce M. Jones from Beaver Falls, Pa., to its New York office. Mr. Jones was formerly with the Symington Co., Gould Coupler Co. and Ross Meehan Foundries.

POWER PIPING CORP., subsidiary of Blaw-Knox Co., Pittsburgh, Pa., has been awarded a contract to design, engineer, and construct all the steam and high-pressure hydraulic piping, including a boiler plant and heating system, for the new molded plastics plant being erected in Cambridge, Ohio, by the Reynolds Spring Co., Jackson, Mich.; this plant will manufacture a large variety of plastics for household, industrial and automotive use, and a research laboratory for the study and development of new uses for molded plastics will be included in the plant.

THE EAGLE-PICHER SALES CO. has recently approved the following companies as new distributors for Eagle Industrial Insulating Materials, including block and blanket insulation, interior and exterior pipe insulation, fills and waterproofing cements: A. Lynn Thomas Co., Inc., Richmond, Va.; Biggs & Co., Wichita Falls, Tex.; Cleveland Fire Brick Co., Cleveland, Ohio; Darragh Co., Little Rock, Ark.; Donald Sales & Mfg. Co., Milwaukee, Wis.; Edgar H. Pratt Fire Brick Co., Chicago, Ill.; L. A. Foster Engineering Co., St. Louis, Mo.; L. R. Land Construction Co., Oklahoma City, Okla.; Lunsford Welding Shop, Inc., Jackson, Miss.; Michiana Fire Brick Co., South Bend, Ind.; Tri-State Mill Supply Co., Fordyce, Ark.; Western Windmill Supply Co., Sweetwater, Tex.; Woare Builders Supply Co., Decatur, Ill.

APPROVAL OF Appalachian Coals, Inc., of Cincinnati, Ohio, by the National Bituminous Coal Commission as a marketing agency for producers was granted Sept. 23rd. The organization represents producers of over 40 million t. of coal in Kentucky, Tennessee, Virginia and West Virginia and provides technical as well as marketing information to consumers, to assist producer members in their sales work.

ROBERT BISCHOFF, hydraulic engineer, has been placed in charge of all valve engineering for Koppers Co.'s Western Gas Division, Fort Wayne, Ind. This division manufactures hydraulic gates and special valves, as well as gate valves for water works, sewage plants, and the steel, chemical and processing industries. Mr. Bischoff formerly was associated with the manufacture of hydraulic turbines in Switzerland.

PLANS FOR display at the Sixteenth Exposition of Chemical Industries are being rapidly advanced by the more than 250 exhibitors who have engaged space to date. Three floors of Grand Central Palace will be occupied, and indications point to one of the most comprehensive Chemical Expositions in the history of these events. Raw materials and chemical products, laboratory and plant equipment, and the machinery essential to manufacturing in all of the industries based on chemistry and chemical engineering will be shown at the Exposition. It will be held during the week of December 6 to 11, 1937. There will be presented interesting new research achievements.

THE KENNEDY VALVE MFG. CO., of Elmira, New York, has appointed Fred C. Greaves as its representative to cover the complete states of Oregon and Washington. Mr. Greaves' office is at 401 Polson Building, Seattle, Wash.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

required by the Act of Congress of March 3, 1933, of Power Plant Engineering, published monthly at Chicago, Illinois, for October 1, 1937.

State of Illinois, } ss.
County of Cook, }

Before me, a Notary Public in and for the State and county aforesaid, personally appeared Arthur L. Rice, who, having been duly sworn according to law, deposes and says that he is the Editor of the Power Plant Engineering and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, Technical Publishing Co., Chicago, Ill.

Editor, Arthur L. Rice, Chicago, Ill.

Managing Editor, R. E. Turner, Chicago, Ill.

Business Manager, E. R. Shaw, Chicago, Ill.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the name and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

Technical Publishing Co.
E. R. Shaw, Chicago, Ill.
Arthur L. Rice, Chicago, Ill.
K. L. Rice, Chicago, Ill.
Madge W. Rice, Wilmette, Ill.
Charles S. Clark, Chicago, Ill.
R. E. Turner, Chicago, Ill.
A. W. Kramer, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

There are none.

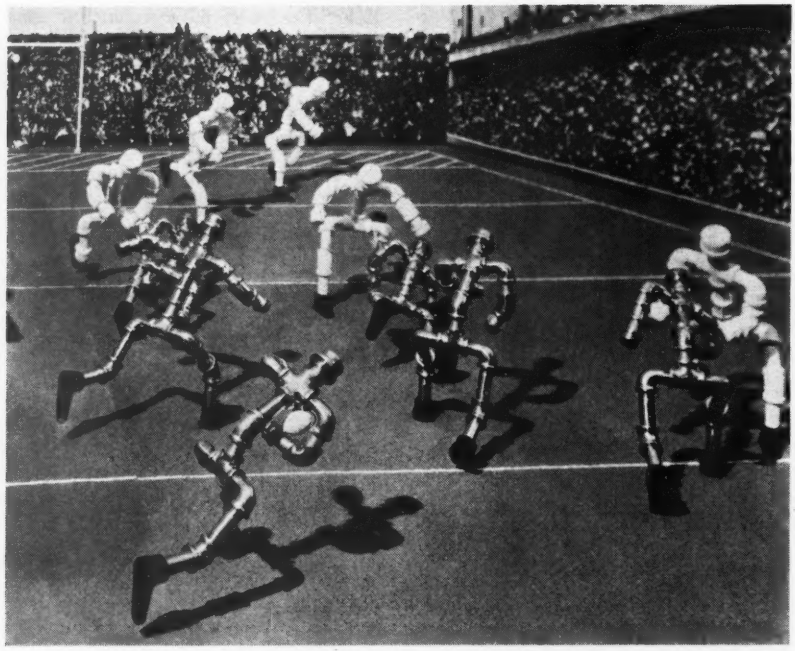
4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholders or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the twelve months preceding the date shown above is ..... (This information is required from daily publications only.)

TECHNICAL PUBLISHING CO.
ARTHUR L. RICE,
Editor.

Sworn to and subscribed before me this 21st day of September, 1937.

[Seal.] JOHN O. AARVOLD,
Notary Public.



Crane Co. Launches Grid Season

FROM RUBBER toe to helmeted top these hard driving gridiron huskies were constructed in their entirety from brass fittings and other accessories in the stock of Crane Co., Chicago. They have been placed in a realistic setting and the display now is touring the country, with the season ending in Los Angeles at the time of the annual football classic, the Pasadena Rose Bowl game.

British Station Performance

DURING the 12 mo. covered by the recently issued 1936 report of the British Electricity Commissioners, 442 stations generated approximately 21,640 million kw-hr. This represents an increase of 13.98 per cent over 1935 although the total number of stations decreased from 458. Of the 20,530 million kw-hr. sent out, some 19,627 million were supplied by 258 steam-operated stations and 34 of these did better than 200 million kw-hr. each.

This year the station efficiency has been calculated on a sent-out rather than a generated basis and the highest thermal efficiency, 27.63 per cent, was made at the Battersea Station operating on a 60.8 per cent load factor. Dunston Station with 26.87 per cent efficiency was second; Barking B with 26.54 per cent, third; Clarence Dock with 25.39 per cent, fourth; and Ironbridge with 24.98 per cent, fifth. Sixteen other stations did better than 20 per cent on the kilowatt-hour sent out basis.

High Temperature Pipe Specifications

AMONG the new A. S. T. M. specifications recently approved for publication is A-206—37 T covering carbon-molybdenum alloy-steel pipe for service at temperatures from 750 to 1000 deg. F. This alloy was formerly incorporated in the standard specifications, A 158-36, for seamless alloy-steel pipe for service from 750 to 1100 F. Due to the widespread use of the carbon-molybdenum type of seamless pipe in the power industry, separate specifications were considered desirable but because of its creep strength above 1000 deg. F. and its oxidation resistant properties, it was felt desirable to limit the temperature to 1000 deg. F. rather than the former figure of 1100 deg. F. There is presented as information in an appendix a table of thicknesses and sizes agreed upon by the Prime Movers Committee of the Edison Electric Institute.

Existing standard specifications A 158 were revised by the incorporation of five new grades of steel, the specifications in their latest form giving requirements for eleven different grades. It was felt desirable to revert the specifications from the status of a formal standard to a tentative. Extensive changes were also approved in the tentative specifications for alloy-steel bolting materials for service from 750 to 1100 deg. F. (A 193—37 T). This specification now includes chemical and physical properties for a number of grades of bolting steels in the body of the specification.

The Dow Chemical Co.

MAJOR EQUIPMENT and auxiliaries for a new high pressure top installation expected to be in operation about May 1938 have recently been purchased by The Dow Chemical Co., Midland, Mich. The Foster Wheeler boiler, complete with economizer, tubular air heater and water cooled slag tap furnace will have a capacity of 300,000 lb. per hr. at 1250-lb., 850 deg. F. at the superheater outlet. The new 1250-lb. G. E. turbine unit, rated at 7500 kw., 2300 v., 3 ph., 60 cycle, 3600 r.p.m., will exhaust to the 385-lb. system in parallel with the present six 385-lb. boilers. Inasmuch as the condenser pressure does not go below 26 in. of vacuum at full load, the high pressure turbine exhaust at a temperature of 600 deg. F. can be used in the present turbines without reheating.

A reducing station will be provided to make the new boiler available for use on the 385-lb. system when the new turbine is down. Both the boiler and turbine will be housed in the present power house building, the boiler in space provided by removing old 150-lb. boilers. It is not expected that the new boiler will retire any of the present 385-lb. boilers from service but it will relieve them to some extent of the present heavy continuous load.

Power Sales Appointments

ANNOUNCEMENT was recently made by Henry P. J. Steinmetz, vice president in charge of sales, Public Service Electric & Gas Co., of the appointment of Herbert W. Bay to be general power representative of the company, succeeding Herbert H. Holding who retired on pension September 13 after 25 yr. service.

In connection with the appointment the following other promotions are announced: Robert G. Ely to be assistant general power representative succeeding Mr. Bay. Spencer A. Moore to be power representative in the Jersey City district of the company, succeeding Mr. Ely.

Starting with Public Service on November 10, 1927, as power representative in Jersey City, Mr. Bay later held a similar position in Newark and in Elizabeth and on October 1, 1931, was appointed agent at Bayonne. He was promoted to assistant general power representative January 1, 1935. Mr. Bay is a graduate of the University of Nebraska.

Mr. Ely started with Public Service in September, 1926, as a cadet in the power sales department after graduating from Cornell University with a degree in mechanical engineering.

Mr. Moore, a graduate of Rensselaer Polytechnic Institute in 1926 with a degree in electric engineering, began a cadet course in the power sales department of Public Service, in September of that year.

APPOINTMENT of James Delinage Ross, Superintendent of the Seattle City Light Department, and Commissioner of the Securities Exchange Commission, as Administrator of the Bonneville project has been announced by the U. S. Department of the Interior. Under legislation passed at the last session of Congress, the Administrator, who will be responsible to and under the general supervision of the Secretary of the Interior, is charged with the duty of administering the transmission and marketing of hydroelectric energy produced by the Bonneville Dam on the Columbia River near Portland and the construction of the

necessary supplemental facilities for transmitting, distributing and marketing electric energy. The legislation provides that the Administrator shall prepare a rate schedule intended to provide the widest possible diversified use of the electrical energy generated at Bonneville. It is provided that uniform rates may be established with the aim of extending the benefits of an integrated transmission system.

BONNELL W. CLARK, Vice-President and General Manager of the Westinghouse Electric Supply Co., recently was elected President of the Company, which has headquarters at 150 Varick Street, New York.

Mr. Clark entered the electrical wholesaling business in 1906, with the Robertson-Cataract Electric Company at Buffalo, N. Y. He has been continuously in electrical wholesaling since that time, except during the period from 1916 to 1920, when he served the Gould Storage Battery Co. as sales manager.

He joined the Westinghouse Electric Supply Company on January 1, 1925, as special representative. He became General Manager in 1929; Vice President and Director in 1932. He served as Chairman of the National Electrical Wholesalers Association from 1930 to 1932.

VOLNEY B. FOWLER, who has been in charge of the Detroit office of the Department of Public Relations of General Motors Corp., has been transferred to the staff of R. K. Evans, Vice President, to supervise public relations activities and advertising in connection with the Corporation's Diesel developments. He will continue to be located in Detroit.

T. A. PEEBLES, Vice President of Hagan Corp., Pittsburgh, Pa., announced receipt of an order from the West Virginia Pulp & Paper Co. for a complete automatic combustion control system for a new 375,000 lb. per hr. 600 lb. pulverized coal fired boiler to be installed at the Piedmont, W. Va., Works, Oliver Bldg., Pittsburgh, Pa.

APPOINTMENT OF W. R. Persons as manager of its Pittsburgh welding sales engineering office is announced by The Lincoln Electric Co., Cleveland, Ohio. Mr. Persons has been in the Pittsburgh office since the fall of 1934, has broad practical experience in arc welding and its applications to manufacture, construction and maintenance, and will be assisted by J. H. Painter, M. S. Schonvizner, R. H. Schuster and H. E. White.

THE SIXTEENTH EXPOSITION of Chemical Industries will be held at Grand Central Palace, New York, during the week of December 6 to 11, 1937, and will provide a preview of plant process machinery, laboratory apparatus, instruments, chemicals and chemical products reflecting the current acceleration along the entire industrial front of American enterprise. Chemicals, raw materials, and manufactured products to be presented at the Chemical Exposition will be portrayed in their relationship to the innumerable industries which depend upon them for starting point, or catalysis of process.

LINDE AIR PRODUCTS CO., Unit of Union Carbide and Carbon Corp., announces that its Boston District office has moved to 441 Stuart St., Boston, Mass.

THE HANCOCK VALVE DIVISION of Manning, Maxwell & Moore, Inc., Bridgeport, Conn., announces the addition of Charles Velie and Raymond Heath to its corps of salesmen. Mr. Velie will make his headquarters in Chicago and Mr. Heath in Dallas.

D. D. FENNELL, consulting engineer of Chicago, was elected president of the National Safety Council at a session held Oct. 15 in the course of the National Safety Congress. Mr. Fennell, who succeeds Dr. C. H. Watson, medical director of the American Telephone & Telegraph Co., brings to the presidency of the Council experience and enthusiasm gained in 20 yr. of active safety work. He was reared in Buffalo, N. Y. After graduating from Hiram College he studied mechanical engineering in Germany and Switzerland.

E. A. BUESCHER has been appointed advertising manager of Island Creek Coal Sales Co., with offices in the Robson-Pritchard Bldg., Huntington, W. Va., as announced by H. A. Glover, assistant to the president of the company, J. D. Francis, president of Island Creek Coal Co., was the first president of Appalachian Coals, Inc., and is still a member of its board of directors.

UTILIZING a new process which permits the manufacture of bleached white sulphite pulp from Southern Pine, the Fernandina Pulp & Paper Co. is erecting a new mill at Fernandina, Fla. The entire construction contract was awarded to the Rust Engineering Co. of Pittsburgh. The mill will have a capacity of 180 t. of bleached sulphite pulp every 24 hr. and the pulp will be used in the manufacture of rayon.

LINDE AIR PRODUCTS CO. is opening a new district office at 729 No. Pennsylvania St., Indianapolis, Ind., to replace the one at the Speedway plant. Territory covered will be from Louisville, Ky., to So. Bend, Ind., and from Columbus and Cincinnati, O., to Illinois line.

ROBINSON Welding Supply Co. has been formed, located at 1921 E. Ferry St., Detroit, 'phone Plaza 8380, to handle produces of Lincoln Electric Co. including arc welders, welding supplies and electric motors. J. M. Robinson has been Detroit district manager for the Lincoln Electric Co. for the past 12 yr., is a graduate of Georgia Tech and has extensive knowledge of arc welding and its applications in construction, manufacturing and maintenance.

ALEXANDER W. LIMONT, JR., has been appointed manager of the Compressor Division of Sullivan Machinery Co. at Michigan City, Indiana. He comes to the Sullivan Machinery Co. from the E. I. Dupont de Nemours organization with whom he has been associated for the past 9 yr., being previously connected with the Norwalk Iron Works of Norwalk, Connecticut, as chief engineer and later with the Ingersoll Rand Co. He is a member of the A.S.M.E. committee which establishes the codes for Unfired Pressure and External Pressure Vessels.

LINCOLN ELECTRIC CO., Cleveland, Ohio, announces the appointment of F. M. Maichle as manager of its Detroit office, 10228 Woodward Ave. Until his new appointment, Mr. Maichle was manager of the company's Pittsburgh office. He studied at the United States Naval Academy, from 1916 to 1928 served the Government as a naval officer, and holds the rank of Lieutenant Commander in the United States Naval Reserve. He was sales engineer for 3 yr. for a steel company, sales manager 3½ yr. for stoking machinery, and has had extensive experience assisting industrial concerns in the application and use of electric welding. Mr. Maichle will be assisted by C. H. Buckmaster, J. F. Cunningham, N. B. Gilliland, T. A. Steel and F. E. Boucher in providing welding supply and consultation service.

ANNOUNCEMENT is made by Jacob T. Barron, vice president in charge of electric operation, Public Service Electric and Gas Co. of New Jersey, of the promotion of Carlton L. Dudley, to be Southern Division Superintendent of the company's electric distribution department, succeeding Theodore B. Morgan, who died September 25. Mr. Dudley has been assistant distribution engineer in the general office of the company at Newark since 1930. He is a graduate of Yale University and entered the employ of Public Service in 1920, starting in the company's cadet engineering course.

WILLIAM R. SWEATT, chairman of the Board of Minneapolis-Honeywell Regulator Co., died on October 12, leaving his wife, two sons and two daughters to mourn their loss. Mr. Sweatt was founder of the Minneapolis-Honeywell Regulator Co. in 1881 and has guided its activities through all the intervening years. He has been personally responsible for the invention, development and improvement of many of the remarkably fine regulating devices manufactured by the company.

PERCY C. BROOKS, former executive vice-president of Fairbanks, Morse & Co., died at his home in Chicago October 15 after a lingering illness of about a year. He was 65 years old. Mr. Brooks started his business career with the Atlanta Machine Works following his graduation from the Georgia School of Technology in 1891. In 1898 he began nearly 40 yrs. association with Fairbanks, Morse & Co. In 1930 he was transferred to Chicago as executive vice-president, a position he relinquished a few months before his death.

NORTHERN EQUIPMENT CO., Erie, Pa., announces the appointment of Cochrane Steam Specialty Co., 80 Federal Street, Boston, Mass., as New England representatives for the sales and service of Copes Feed Water Regulators, Differential Valves, Pump Governors, Reducing Valves, Desuperheaters and allied equipment.

LEHIGH UNIVERSITY, at its Founder's Day exercises at Bethlehem, Pa., Oct. 6, conferred the honorary degree of Doctor of Engineering upon E.G.Bailey, Vice-President of The Babcock & Wilcox Company, New York, and President of the Bailey Meter Company, Cleveland, Ohio, for "notable and distinguished accomplishment in the field of combustion and steam engineering." In 1930 Mr. Bailey was awarded the Longstreth Medal by the Franklin Institute, and in 1936 the Lamme Medal by Ohio State University.

J. A. SCHALLENBERG, recently appointed Assistant Comptroller of Worthington Pump and Machinery Corp., assumed his new responsibilities on October 1. He has served the corporation in various capacities in the treasury and accounting departments during the past 20 yr. and is exceptionally well qualified for this position. Since 1930, he has served as special representative of the treasury and accounting departments, with headquarters in Paris, France, and while the affairs of the foreign subsidiary companies will continue to have his attention, the major portion of his time will now be devoted to the parent corporation.

ARTHUR T. COX, JR., has been appointed manager of the Tri-Cities office of the Lincoln Electric Co. of Cleveland, Ohio, with offices at 1205-09, Fourth Ave., Moline, Ill. Mr. Cox has been is the Chicago office and succeds J. B. Flock, who is taking a year's leave of absence.

ROGER B. MCWHORTER, chief of the bureau of engineering of the Federal Power Commission has been appointed as the Commission's representative on the Bonneville Dam Advisory Board. He is a graduate of Alabama Polytechnic Institute, has been in charge of engineering for the Commission since 1931 and has been associated with construction of the Hales Bar Dam, Miami (Ohio) Conservancy District, Wilson Dam, New Orleans Levee District and Mississippi Flood Control.

For the Engineer's Library

Any Catalogs that you wish will be gladly sent. Write POWER PLANT ENGINEERING.

HEAT AND ITS CONTROL the sound motion picture produced by Johns-Manville is an important contribution toward effective utilization of heat as it gives actual visualization of what heat is, and the story of its use and methods of conservation. The first official showing of the picture was attended by 150 representatives of the industrial and technical press at New York City, where publication of an authoritative handbook, Heat, which supplements the movie, covering approximately the same ground in greater detail, was announced.

The picture will be shown at engineering society meetings and at special showings to other interested groups. All arrangements for such programs will be handled by Johns-Manville district organizations.

NEW 1937-38 EDITION of the Johns-Manville Industrial Products Catalog is now available, a 64-page book, profusely illustrated, giving information and recommendations on high and low-temperature insulations for industrial needs; specifications on J-M Bonded Asbestos Built-up Roofs and J-M Insulated Roofs; detailed information on J-M Corrugated Transite for roofing and siding; on J-M industrial friction materials; on Transite Electrical Conduit and Korduct, Asbestos Ebony and other J-M electrical materials; on Transite industrial vent pipe and stacks; and on J-M packings and gaskets; on J-M Industrial Flooring Plank, Asphalt Tile Flooring, Steeltex Floor Lath, Welding Wire Reinforcement and materials for sound control of mechanical equipment. Copies of this book, Form GI-6A, are available upon request to Johns-Manville, 22 East 40th St., New York City.

BOILER ROOM SAVINGS, through Burning Lower Grade Coals, through Increasing Steam Capacity is the subject of a paper recently presented before the Engineers' Society of Western Pennsylvania, covering the latest developments in stoker design, such as reliability, capacity, maintenance, operation. Special attention is given to experiences with the new water-cooled Taylor Stoker. Copies are available from the American Engineering Co., Philadelphia, Pa.

WROUGHT IRON for Tank Construction, an 8½ by 11 in. bulletin of 32 p. gives information that has been requested by numerous correspondents on the proper construction of tanks and standpipes for industrial plants, the advantages of genuine wrought iron for such construction and histories and illustrations of many older tanks. Copies may be had on request from A. M. Byers Co., P. O. Box 1076, Pittsburgh, Pa.

NATIONAL ALUMINATE CORP. has recently completed a modern laboratory and office building which is outstanding in appearance and convenience. Arrangement, appointments and reasons for construction are presented by text and illustrations in an interesting and attractive booklet which contains articles by J. T. Meek, editor of Illinois Journal of Commerce, on The Modern Way to Job Concentration, dealing with the planning of the building for its uses, and by Robert E. Hattis, consulting engineer, on the air conditioning system of the building, with reasons and details of the installation. Floor plans and interior views are shown. Copies of the booklet may be had from National Aluminate Corp., 6210 W. 66th Place, Chicago, Ill.

IN THE OCTOBER issue of Valve Values, articles of interest to power plant engineers deal with: Thermal Expansion of Steels and its measurement with regard to "growth" of valves and fittings; a Big Valve for a Top Turbine to handle steam in a 24-in. line between the high-pressure turbine outlet and the 200-lb. station header; Controlling Steam Flow at 350 lb. pressure and 700 deg. F. in volumes of 100,000 to 350,000 lb. per hr. Valve Values is issued by The Edward Valve & Mfg. Co., Inc., E. Chicago, Ind.

HANCOCK FLOCONTROL VALVES are described in a new bulletin designated as 7500-C recently issued by Hancock Valve Division of Manning, Maxwell & Moore, Inc., Bridgeport, Conn. The occasion for the publishing of this bulletin is that these valves have been completely redesigned and prices lowered. The new features and prices are included in the bulletin.

WHEELCO INDICATING PYROMETERS is the subject of Bulletin No. 503 recently issued by the Wheelco Instruments Co., 1929 So. Halsted St., Chicago. These pyrometers range in size from the small portable to the large 8-in. scale wall mounted type. Several new items of combination pyrometers and switches which have recently been developed are described in this new bulletin.

NEW PROFITS in arc welding with the simplified 40 volt Hobart arc welder are discussed in a bulletin recently issued by Hobart Brothers, Hobart Square, Troy, Ohio. This bulletin is attractively illustrated and contains money-making suggestions for job welding shops, blacksmith shops, auto repair shops, machine and tool shops and ornamental iron works.

MOTORCOMPRESSORS, described in bulletin No. 3166 of Ingersoll-Rand, 11 Broadway, New York, are stationary, vertical, single-acting, two-stage, motor driven air compressors with the intercooler and the radially-placed cylinders air-cooled. The compressor crankshaft carries the motor rotor, and the compressor frame carries the motor stator. Flexible-coupling and V-belt drives are also available.

LAMINATED Shim Co., Long Island City, N. Y., has issued a folder on specifications for use of its laminated brass shim stock (Laminum) in convenient form for designing engineers. Copies on request.

HEAVY DUTY REFRACTORIES which are treated in a bulletin recently published by Norton Co., Worcester, Mass., consist of bricks, plates, fabricated muffles, heavy tubes, batts, saggers, burner blocks, and miscellaneous shapes for furnaces. These refractories are made of electrically fused alumina and silicon carbide, and the bulletin is a treatise on the use of these materials for use in all kinds of furnaces used in industries.

BROADSIDE T is a publication of the Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa., presenting for the first time in one publication the company's line of Vapocarb-Hump and Homo furnaces for hardening, tempering and nitriding.

STEAM PURIFIERS, their construction details and styles manufactured by the Cochrane Corp. of Philadelphia, are made the subject of Publication No. 2725 recently issued by the Corporation. The bulletin is a presentation of the benefits to be secured by the installation of a purifier to eliminate damage that may be caused by the presence of moisture and solid impurities in the steam.

PREVENTING Welding and Cutting Fires, a booklet on safe practices in the welding industry, of interest to industrial users is issued by the Linde Air Products Co., New York, N. Y.

SPECIFICATION SHEETS have recently been issued by Universal Motor Co., Oshkosh, Wis., covering Universal Electric Plants ranging in capacities from 400 watts to 25 kw. These units consist of a.c. or d.c. generators driven by internal combustion engines.

THE BROWN INSTRUMENT CO., Philadelphia, Pa., has just published a new 48-page catalog No. 1102 covering the complete line of Brown Potentiometer Type Pyrometers and including the new Brown Electr-o-Line Controllers and the Brown Proportioning Control System.

THE HAYS CORP., Michigan City, Ind., is distributing a four page bulletin entitled Marshfield Modernizes, describing the installation of its equipment at the Marshfield, Wis., municipal lighting plant.

BULLETIN NO. 373 of the Bender Warrick Corp., Birmingham, Mich., on Floatless Pump Controls is a 12-page catalog discussing the principle of operation and varied industrial applications of the B/W induction relay.

A REVISED, six-page, illustrated Bulletin No. 35-76 on ADSCO Water Heaters for industrial and institutional installations including the Type E heater for gravity recirculation, submerged heater and condensate cooling service and the Type F heater for maintaining suitable water temperatures to prevent the freezing of water in elevated steel or wooden tanks, is available from the American District Steam Co., North Tonawanda, N. Y.

BULLETIN NO. 361-S recently issued by Klipfel Mfg. Co., Chicago, describes three new types of reducing valves, giving not only illustrations showing the interior construction but tables of dimensions, capacities and characteristic curves of their operation.

AMERICAN GAS ASSOCIATION, 420 Lexington Ave., New York City, has reprinted a number of papers and committee reports prepared during 1937. These include the following: Combustion Controls for Gas Fired Boilers—Their Importance —The Utilization of Natural Gas as a Fuel for Large Power to Users and Utilities, by L. S. Reagan, 19 pages; price 40 cts. Steam Generation Committee Report, W. W. German, chairman, 25 pages; price 50 cts. Gas Engine Power Committee Report, E. J. Hatzenbuehler, chairman, 10 pages; price 20 cts.

NUMEROUS AND VARIED uses of the unique IMO rotary oil pump are shown by publication L-32-10, distributed by the De Laval Steam Turbine Co., Trenton, N. J., a pump designed to run at ordinary electric motor and steam turbine speeds, used principally for supplying fuel oils of all grades to burners and for transferring or circulating lubricating oils, and having only three moving parts. Applications shown range from small lubricating pumps built into other machines, to pumps supplying oil to hydraulic pressure systems at 500 lb. per sq. in., and Bunker C oil in large quantities to burners in central stations and on large steamships.

ARC WELDING with the new 40-v. simplified arc welder is treated in a catalog just issued by Hobart Brothers Co., Hobart Square, Troy, O. It shows the uses of Hobart's new motor horsepower control in this modern welding equipment, that lets you use half the horsepower of a normal welder on light work and full horsepower on heavy work with a substantial saving in current costs.

TUBE CLEANERS, a 24-p. treatise on Liberty and Lagonda cleaners, describes and illustrates interestingly, the various types for cleaning boiler tubes and for special uses such as condensers, arch tubes for locomotives and large piping. Copies will be gladly sent on request by Elliott Co., Lagonda-Liberty Tube Cleaning Dept., Springfield, Ohio.

NATIONAL Radiator Corp., Johnstown, Pa., is sending out a bulletin, Form 301, giving specifications for National oil heating units, with details of construction, sizes and capacities.

JAMES G. BIDDLE Co., 1211 Arch Street, Philadelphia, Pa., has issued a new bulletin, No. 1515, describing "Jagabi" rheostats. These are fine instruments for the fine adjustment and control of electric current made in a variety of styles for various purposes. The bulletin contains complete information on their construction as well as technical data for making proper selection for particular purposes.

UNCOMMON OSCILLOGRAMS of Common Electric Circuits, by G. V. Mueller is the title of bulletin No.1, Vol. XXI Research Series No. 56 issued by Purdue University, Engineering Experiment Station.

CORNELL-DUBILIER ELECTRIC CORP. announces the release of its new power factor folder No. 143, the first of a series describing C-D's new line of capacitors for power factor correction on electric distribution systems. It gives the inside story of a modern pole-type power factor capacitor, of interest to industrialists and electrical engineers and is available by addressing request to the Cornell-Dubilier Electric Corp., South Plainfield, N. J.

REPAIR OF PIPE LEAKS without shutoffs is the title of a handbook published by M. B. Skinner Co., South Bend, Ind., which discusses the question of leaks in pipe lines and joints and tells how repairs can be made without service interruptions. It is furnished without cost on request to men responsible for pipe maintenance.

ALUMINUM PAINT Manual, a 100-p. booklet for those interested in the use of aluminum paint is issued by Aluminum Co. of America, Pittsburgh, Pa. It treats of characteristics, vehicles for carrying aluminum pigment, methods of application and use.

FOUR BULLETINS of interest to engineers have recently been published by the Engineering Experiment Station of the University of Illinois, Urbana, Ill. They are paper bound, measure 6 by 9 in., and average about 30 pages each. Prices are given but there are a few copies of each available for free distribution.

Circular No. 28 (40 cents), by John O. Kraehenbuehl is An Investigation of Student Study Lighting, covering several types of typical lamps, including the goose-neck, E.I.S. study lamp, drop light and ind.rect light. From tests each was rated on a scale of 25 points covering the quantity of illumination, uniformity of illumination, indirect glare, etc. Indirect lighting is best but the power consumption is high. The better direct lighting lamps received 17 or 18 out of a possible 25 points.

Circular No. 29 (35 cents), by John O. Kraehenbuehl is Problems in Building Illumination. This discusses the general principles which underlie the necessity for, and the problems presented in obtaining good lighting.

Bulletin No. 295 (30 cents), by Wilbur M. Wilson and Joseph Marin is a report on tests of thin hemispherical shells subjected to internal hydrostatic pressure. These built with steel and aluminum alloys were made to simulate service encountered by holders for gas under pressure. Conclusions state that the allowable stress of the material used may be taken equal to stress allowed the same material subjected to simple tension.

Bulletin No. 293 (50 cents), by Thomas J. Dolan is a report of tests made on the combined effect of corrosion and stress concentration at holes and fillets in steel specimens subjected to reversed torsional stresses. Corrosion decreases the tortional fatigue of all steels tested. The effect was greatest on chrome nickel heat treated steel and negligible on low carbon steel.

RECENT DEVELOPMENTS in higher steam pressures and temperatures, in boiler and combustion equipment, in steam turbines and in the application of exhaust and bled steam, and how these have all combined to make possible great economies in the generation of power and heat for buildings and industrial plants, is the subject of a 12-p., 11 by 16-in. brochure entitled Modern Turbines to Reduce Costs, issued by the De Laval Steam Turbine Co., Trenton, N. J., showing how cheaper fuels can be burned with less labor and with higher efficiency, how more power can be generated from a given weight of steam, how less building space is required, or increased demands for power can be met without increased costs for buildings and foundations. In many cases existing equipment, if in good condition, can be retained by superposing a high-pressure boiler and turbine, the latter exhausting into the present steam mains. A great variety of steam turbine applications is set forth in the text and illustrations of this publication, which will be sent free upon request.

HANCOCK VALVE DIVISION, Manning, Maxwell & Moore, Inc., Bridgeport, Conn., has just published a 4-page illustrated bulletin describing the new Hancock Duravalve, the distinctive new valve with leakproof integral Stillite seat developed expressly for high pressure, high temperature service.

COVERING the complete line of Synchro Diaphragm Control Valves, Bulletin No. 461 of The Bristol Co., Waterbury, Conn., gives information regarding the constructional features, the operating characteristics and the various types of Bristol's Synchro Diaphragm Valves and their application to typical installations, where temperature, pressure, liquid level, flow and humidity are controlled pneumatically.

PICTORIAL PRESENTATION of the story of steel from iron ore mine to finished products has just been published by The Youngstown Sheet & Tube Co., entitled What We Make and How We Make It. Using action photographs and brief, to-the-point captions, the book contains 115 pages of basic steel information on iron ore mining, pouring of ingots, cutting of billets, manufacture of flat rolled steel, tin plate, pipe, rods and wire, nails and forged steel unions. Those interested in the book may obtain copies by writing the Sales Promotion Department of The Youngstown Sheet & Tube Co., Youngstown, Ohio.

LINDE AIR PRODUCTS Co., Unit of Union Carbide and Carbon Corp., 205 East 42nd Street, New York, N. Y., announces publication of a folder, entitled Steel Hard-Facing Procedure, which presents detailed instructions for applying Haynes Stellite to steel wearing surfaces. It begins with the preparation of the steel part and discusses each operation, including preheating, hard-facing, cooling, and finish grinding, with general recommendations for the proper grade of alloy for hard-facing many machine parts and a discussion of blowpipe tips, sizes and methods for drawing out hard-facing welding rod. Copies are available without charge.

YARNALL-WARING Co., Chestnut Hill, Philadelphia, has recently issued its Bulletin WG-1805 covering the Yarway line of water columns and water gages for boilers, and giving complete details of the Yarway floatless Hi-Lo water alarm column and the Yarway line of water level gages for pressures up to 1500 lb.

FROM THE Brown Instrument Co., Philadelphia, Pa., comes a folder describing its Periodic Instrument Service of checking and maintenance, to ensure best condition and operation of equipment. Copies available on request.

LUBRICATION AND LUBRICANT STANDARDS are covered by two publications of unusual interest recently published by the American Society for Testing Materials, 260 So. Broad St., Philadelphia, Pa.

First is a reprint of a Symposium on Lubricants held in Chicago in 1937. This consists of four papers, Engine Deposits, Causes and Effects; Automotive Bearings, Effect of Design and Composition on Lubrication; Addition Agents for Motor Oils and How to Select a Motor Oil from the Standpoint of the Consumer. Although aimed primarily at the automotive field, the papers cover a complete review of modern lubrication practice. The papers and discussion cover 89, 6 by 9 in. pages and the cost of a paper bound volume is $1.25, or, cloth bound, $1.50.

The second volume contains 378 pages and includes in the latest form 58 test methods on petroleum products and lubricants. This publication is paper covered and sells for $2.00 a copy. Special prices on quantities of 10 or more are available on both volumes.

New Engineering Books

COLLECTIVE BARGAINING. By R. D. Bundy. 44 pages, cloth; 5 by 8 in. Published by the National Foremen's Institute, Inc., 60 E. 42nd St., New York, N. Y., 1937. Price, $1.00

Collective Bargaining is a term, these days, which means many things to many people and there is a good deal of confusion about it Since it is a term associated with strikes and labor disturbances to many it has taken on a meaning not entirely wholesome, and, therefore, not a fit subject for dispassionate discussion in polite society. This is no doubt only natural; the suddenness with which collective bargaining came upon industry with the advent of the N. R. A. brought with it much confusion and a great deal of uncertainty regarding labor's relation to industry and this stirred up violent prejudices.

The purpose of this little book is to approach the subject of collective bargaining in an objective manner, to look at it as a problem which is facing management and workers for solution, to consider it as the resultant of those forces which have played upon the workman for years, to analyze it with the view of making the necessary adjustments and to suggest a procedure for eliminating the causes which have brought it about.

ENGINEERING THERMODYNAMICS. By Newton C. Ebaugh. Published by D. Van Nostrand Co., Inc., 250 Fourth Ave., New York, N. Y. Size 6 by 9 in., cloth bound, 199 pp. Price $2.85.

Thermodynamics, the foundations upon which the power plant industry rests, consists of a relatively few principles determined by experiment over a limited range. These fundamental principles must be thoroughly understood if they are to be applied intelligently to practical engineering application.

This particular book is arranged with the fundamentals covered in the first eight chapters with the remaining five discussing applications in a general way. It is intended as a text book for students who have a working knowledge of inorganic chemistry, general physics and mathematics through calculus and the author, head of the mechanical engineering department of the University of Florida, has omitted detailed applications of engineering equipment "purposely . . . since most technical schools prefer to give courses in steam power engineering, internal combustion engines, heating and ventilation, refrigeration and air conditioning, in addition to the courses in thermodynamics."

There may be some question as to whether a book which outlines a course so important to engineering students in 109 pages of mathematical treatment, adequately covers the purpose for which it was intended. There is no doubt however, that the concise logical presentation makes it a valuable book for engineers who already have a working knowledge of thermodynamics and wish to review some particular phase of theory without reading through too many pages. Its value for this purpose is enhanced by a large number of problems at the end of each chapter with the answers given and three folded charts in the back of the book large enough for practical use.

COAL—ITS CONSTITUTION AND USES. By William A. Bone and Godfrey W. Himus. Published by Longmans, Green & Co., 114 Fifth Ave., New York City. Size 6½ by 10 in., cloth bound, 620 pages. Price $7.50.

For almost a generation—"Coal and Its Scientific Uses" by Bone has been a classic text known the world over. Unfortunately, its publication antedated the remarkable post war developments in coal technology, and although many of these were anticipated, absence of the actual course of development placed ever increasing limitations on its practical use for all but fundamentals. The engineering world is indeed fortunate that the author and one of his assistants at the Imperial College of Science and Technology, London University, undertook the preparation of a new book along the same general lines but stressing post war developments.

Covering all phases of the economic, geological, chemical and technological aspects of the subject, the book paints a remarkable world wide, overall picture of an industry and its problems. The introductory chapter on post war economic aspects of coal from the standpoint of Great Britain and the Empire, and the second chapter on Britain's coal problems are remarkably good. After all, Great Britain's coal problems are the coal problems of the world. The chief difference between those in Great Britain and this country, for instance, is that in Great Britain coal is a matter of national importance tied up with the survival of a nation in the industrial and military competition with other countries. In this country it is largely a matter of survival of an industry against the inroads of competitive fuels.

The balance of the book deals with technical features of the industry, chemical constitution, geological history, classification and distribution of the world's coal resources. A series of chapters cover the uses of coal, preparation for market, pulverized coal, boiler design, smoke abatement, carbonization, hydrogenation, domestic heating, surface combustion, power production and fuel economy in the iron and steel industry. The last 32 pages form a special chapter on fuel economy and heat transmission in industrial furnaces by R. J. Sarjant, formerly an associate of the main authors but now with Messrs. Hadfield's, Ltd.

All in all, it is a most remarkable book of wide appeal to all technical men engaged in the production or use of fuel. Scientific principles are set forth in language clear and free from mystifying terminology and sufficient historical matter has been included to make a readable volume and show how modern developments are the result of more than a century's work and effort.

THERMODYNAMICS FOR ENGINEERS. By Henry F. Gauss. Published by Edwards Brothers, Inc., Ann Arbor, Mich. Size 8½ by 11 in., 414 pp., lithoprinted. Price $6.30.

Engineering thermodynamics, concerned primarily with the transformation of heat into mechanical energy, forms the foundation of the power plant industry. Upon this solid foundation, electrical engineering has erected an elaborate superstructure of large public utility systems and made possible the practical developments predicted from thermodynamic theory generations ago.

The book is divided into ten chapters and four appendices. These chapters discuss briefly but clearly and thoroughly: Perfect and real gases; working fluids used in various cycles; conversion of heat energy into mechanical energy; steam nozzles; steam turbines; all types of refrigeration; internal combustion engines; and air compressors. The appendices, which are in fact additional chapters, cover: Heat balance from the fuel or boiler standpoint; practical calculation of steam pipe sizes; methods of graphical computation so important to the engineer; and the theory of orifice ratios as applied to fans. Many of the chapters have a large number of problems to assist the reader or student in understanding the fundamental theory presented in the text.

Inasmuch as thermodynamics is a more or less exact science based upon mathematical definitions neither theory or its practical applications can be well presented without mathematics so formulas and their derivations are common throughout the book. At least a superficial knowledge of differential and integral calculus is of course of considerable advantage in studying this subject but if the reader is willing to accept the final formula without question a detailed knowledge of the derivation of the various formulae is not necessary for a practical working knowledge of the subject. Although arranged primarily as a textbook, the practical treatment in logical order makes the book valuable for the practical engineer while the concise treatment and complete table of contents and index makes it unusually valuable as a reference book for fundamental theory.

A-C NETWORK OPERATION. Publication No. E8 of the Edison Electric Institute, 420 Lexington Ave., New York, N. Y. Size 8½ by 11½ in., 40 pp. Price to nonmembers in U.S.A. $1.60, foreign $1.75.

This is a report of the transmission and distribution committee for 1934 and 1935 and consists largely of installation and performance data. Peak load served by low voltage a.c. networks in 1935 showed increase of 20.5 per cent, while the capacity to serve this additional load increased but 17.35 per cent, resulting in an improvement in the load-transformer capacity ratio.

THERMODYNAMICS. By H. A. Everett. Published by D. Van Nostrand Co., Inc., 250 Fourth Ave., New York City. Size 6 by 9 in., cloth bound, 415 pp. Price $3.75.

Considering the flood of recent books dealing with engineering thermodynamics, this book, written by the head of the Department of Mechanical Engineering of Pennsylvania State College, is somewhat of an innovation. It is definitely a text for students in engineering colleges, assumes a preceding knowledge of calculus and a follow up by the applicational or professional courses such as power plants, internal combustion engines, refrigeration, steam turbines, etc., for the practical application. 'It deals entirely with thermodynamics from the theoretical side and as such deals much more thoroughly and

completely with theory than can those books devoted primarily to the engineering application.

Due to the fact that the kinetic theory of heat permits presentation of a very tangible picture of thermodynamic phenomena, considerable stress is laid on the theory. The few fundamental concepts upon which thermodynamics are based are grouped in one chapter. This is followed by the application of theory to the simplest fluids, the perfect gas and consideration of the devices which use these gases in an engineering way. Vapors are considered a narrowed portion of the gaseous phase.

Special attention has been directed to the chapter dealing with gases to the departure of actual gases from the perfect gas and charts which evaluate the change in the gas constant are original and have been found convenient to the author in his past work. To the student or to the engineer interested in making a complete and thorough study of thermodynamics or in making professional use of the subject, this book will be found to be complete and valuable, either as a text or as a reference.

MODERN REFRACTORY PRACTICE—Second Edition. Published by Harbison-Walker Refractories Co., Pittsburgh, Pa., 1937. 296 pages, 52 illustrations, 97 charts and tables, index.

This publication is actually a practical service handbook, an up-to-date technical review, and a complete catalog combined in a single volume. While it follows the general lines of the first edition, published in 1929, the book has been completely rewritten, and increased in size from 180 to 296 pages. An entire chapter is devoted to suggestions of a practical nature regarding the selection, care and use of refractories, including ordering and handling brick, bonding methods, the best ways to provide for thermal expansion, arch construction, design and placement of skewbacks, and factors affecting service life. Another new chapter, "Refractories and Their Properties", gives basic technical data on the composition, structure, and properties of refractories as affected by furnace temperatures, furnace gases and slags. A glossary and a selected list of minerals and rocks of significance to those concerned with refractories is unusually complete. The price of the book is $2.50, but it is offered without charge to users of refractories. For student use, the price to faculty members of universities and colleges, is $1.25 for single copies and $1.00 in lots of six or more.

DEGREE DAY HANDBOOK. By Clifford Strock, and C. H. B. Hotchkiss. Published by The Industrial Press, 148 Lafayette St., New York City. Size 6 by 9 in., 291 pp., flexible fabricoid binding. Price $3.00.

Experience has shown that the heat required or fuel necessary to heat a building is a function of the number of degrees the average outside temperature falls below an assumed figure. Ordinarily this is taken as 65 deg. F. and a degree-day has become an established factor in the life of an engineer. This book tells thoroughly and completely what a degree-day is and how to use the degree-day table. The explanation of the tables is largely in the form of 46 examples worked out in the early part of the book.

The balance of the book is largely occupied by tables and charts. Degree-day data by month is given for 1064 cities and the number of degree-days by month in recent years for 54 large cities. The length and average temperature of the heating season in 411 cities and summer cooling data for 18 cities; prediction of fuel consumption, efficiencies of fuels, guide to operating efficiency, the degree-day in sales promotion; and market research and a discussion of the base temperature of 65 deg. F. are other topic headings.

STEEL SQUARE POCKET BOOK. By Dwight L. Stoddard. Published by the Scientific Book Corp., 15 East 26th St., New York City. Size 4 by 6 in., 174 pp., cloth bound. Price $1.00.

Although written primarily for the carpenter, this book has for many years been a standard guide for the practical engineer who must lay out work of his own. The carpenter's steel square is one of the oldest and at the same time most valuable and comprehensive tool or instrument which has ever been developed. This book outlines in a practical way many of its uses in layout work, or making different figures or calculating many problems involved in obtaining the proper cut for hoppers, towers, braces, trestles, stairs, etc.

Photo, Kaufmann-Fabry

PHOTOMURALS OF POWER PLANTS AID COMPANY'S SALES

POWER COMPANIES and other public utilities have sales and merchandising problems just as pressing and definite of those of any merchant. Modern methods are being adopted by some of the companies in presenting their sales story. An example of this is seen in the case of the Public Service Company of Northern Illinois which has recently installed a series of striking photomurals in its executive offices at Chicago to dramatize service facilities.

The photomurals, executed by the Kaufmann and Fabry Co., depict interior and exterior views of the principal interconnected power plants in the Chicago and outlying area and a huge photomural map reveals huge transmission and distribution net-work. Without leaving their chairs, officials and power users can visualize an immense background of physical equipment and formulate a clear idea of the facilities to render service anywhere within the area served.

Prepared from ordinary-sized camera pictures, the huge photomurals beautify the offices.

Power Plant Construction News

Conn., Hartford — Sterling Blower Co., Windsor Street, manufacturer of dust-collecting systems, plans installation of electric power equipment in new one and two-story addition to plant, for which superstructure will begin soon. Entire project will cost over $60,000.

Ga., Atlanta—Water Bureau, City Hall, plans early call for bids for motor-driven pumping machinery and auxiliary equipment for municipal waterworks plant, to replace present obsolete units. Work will be carried out in connection with a $1,000,000 expansion and improvement program in waterworks stations and system. Wiedeman & Singleton, Candler Building, are consulting engineers.

Ill., Chicago—Glidden Soya Products Division, 5165 West Moffat Street, has authorized a new three-story boiler house at plant, and will begin work on project at early date. Cost over $50,000, with equipment. N. Ronneberg, Inc., 10 South La Salle Street, is consulting engineer.

Ind., Butlerville—Board of Trustees, Fort Wayne State School, Butlerville, D. L. McCauley, superintendent, has plans under way for new steam power house at institution. Fund of $250,000 has been authorized for station and two new dormitory buildings. Bids will be asked soon on general contract. Pohlmeyer & Pohlmeyer, Central Building, Fort Wayne, Ind., are architects.

Iowa, Fort Madison—E. I. du Pont deNemours & Co., du Pont Building, Wilmington, Del., plans installation of electric power equipment in new paint and enamel works at Fort Madison, where company has acquired former plant of Perfection Tire Co., idle for number of years, and will modernize and expand for plant. Entire project will cost over $400,000.

La., Baton Rouge—Standard Oil Co. of Louisiana, Inc., Baton Rouge, plans installation of power equipment in connection with extensions and improvements in local oil refinery. Work is scheduled to begin soon. Entire project will cost close to $2,500,000.

Me., Lewiston — City Council has plans maturing for new municipal hydro-electric generating station on Lake Auburn, where site has been acquired. Also will modernize and improve present steam-electric power plant, including new equipment installation. Fund of $102,600 has been secured through Federal aid for project.

Mich., Dearborn—Ford Motor Co., plans expansion in main power plant at River Rouge works, including installation of new 110,000-kw. turbo-generator unit and accessories, high-pressure boilers and other equipment. Cost estimated over $1,500,000. Awards for prime movers are being made and contracts for other equipment will be placed soon. Company also will install electric power equipment in group of new additions to plant for large increased production. Entire project will be carried out over a period of months and will cost in excess of $35,000,000.

Mich., Detroit — National Cylinder Gas Co., 205 West Wacker Drive, Chicago, Ill., manufacturer of industrial oxygen, etc., plans installation of power equipment in new plant in Ferndale district, Detroit, for which superstructure will begin soon. Entire project will cost close to $200,000.

Miss., Morton—Adams-Edgar Lumber Co., plans installation of power equipment in connection with rebuilding of portion of mill, recently destroyed by fire, including power station, saw mill, machine shop and other structures. Loss estimated at $100,000.

Miss., Pascagoula—Jackson County Woolen Mills, Pascagoula, recently organized, plan installation of electric power equipment in new local mill. A boiler plant will be built. Entire project will cost over $75,000.

Neb., Alliance—City Council has plans maturing for extensions and improvements in municipal electric power station, including installation of new turbo-generator unit, high-pressure boilers, condenser and auxiliary equipment. Cost close to $240,000. Black & Veatch, 4706 Broadway, Kansas City, Mo., are consulting engineers.

Neb., Fremont—City Council is having plans prepared for expansion and improvements in municipal electric power plant, including installation of considerable new equipment for increased capacity. Proposed to take bids soon. Cost close to $225,000. Black & Veatch, 4706 Broadway, Kansas City, Mo., are consulting engineers.

N. M., Artesia—Central Valley Electric Corporation, Artesia, I. S. Reser, president, has plans maturing for new steam-electric generating plant on local site, for service for new rural electrification system. Plant will cost about $125,000. Financing has been arranged through Federal aid. E. T. Archer & Company, New England Building, Kansas City, Mo., are consulting engineers.

N. Y., Brooklyn—American Safety Razor Corporation, 315 Jay Street, has plans maturing for extensions and improvements in boiler plant, including installation of new equipment. No estimate of cost announced. William Higginson & Son, 101 Park Avenue, New York, N. Y., are architects.

N. C., Asheboro—Asheboro Hosiery Mills, Inc., plan installation of electric power equipment in new one-story hosiery mill, 117x120 ft. Entire project will cost over $65,000. H. V. Biberstein, 1600 Elizabeth Avenue, Charlotte, N. C., is architect.

N. C., High Point—City Council has authorized surveys and estimates of cost for a proposed municipal hydroelectric generating station on Yadkin River, including transmission line to city. Proposed to carry out financing through Federal aid. E. M. Knox, city manager, is in charge.

Ohio, Gambrinus — Timken Roller Bearing Co., Dueber Avenue, Canton, Ohio, plans installation of power equipment in proposed new plant on site at Gambrinus, near Canton. Entire project will cost over $600,000.

Ohio, Niles—Youngstown Steel Car Corporation, Niles, plans installation of electric power equipment in new one-story addition to mill, 80x200 ft., entire project reported to cost over $85,000. Work is scheduled to begin this fall.

Ohio, South Zanesville—Burley Clay Products Co., plans installation of power equipment in connection with proposed rebuilding of flower pot and stoneware products manufacturing plant, recently destroyed by fire. Loss estimated close to $100,000.

Okla., Tulsa — Stanolind Oil Co., Philcade Building, Tulsa, plans installation of electric power equipment in new one-story chemical plant on local site. Entire project will cost over $75,000.

Ore., Klamath Falls—Crater Lake Box & Lumber Co., plans installation of power equipment in connection with proposed rebuilding of mill, recently destroyed by fire. A new boiler house will be built. Loss estimated close to $50,000.

Ore., Portland—Blake-David Lumber Co., North Portland Boulevard, and Northwest Box Co., with plant on adjoining site, plan installation of power equipment in connection with rebuilding of portions of mills, recently destroyed by fire. Entire loss estimated at $125,000. New boiler house is planned.

Pa., Butler—American Rolling Mill Co., Middletown, Ohio, plans installation of electric power equipment in connection with expansion and improvements in branch mill at Butler. Entire project will be carried out over a period of months and is reported to cost close to $2,000,000.

Pa., Johnstown—Bethlehem Steel Co., Bethlehem, Pa., plans installation in new addition to Cambria mill at Johnstown, for production of steel axles and kindred products. Entire project will cost over $500,000. Work will be placed under way at once.

Pa., Reading—City Council is planning bond issue of $4,700,000 for new municipal steam-electric generating plant, recommended in report of Burns & McDonnell Engineering Company, 107 West Linwood Boulevard, Kansas City, Mo., consulting engineer, which has made survey of project for city. The proposal for bond issue will be placed before voters at November general election.

Texas, Dallas — Gregory-Robinson-Speas, Inc., Paris, Texas, manufacturer of vinegar products, plans installation of electric power equipment in new multi-story plant at 8668 Maple Avenue, Dallas. Work is scheduled to proceed at once. Entire project will cost over $80,000, including tanks, conveyors and other machinery.

Texas, Somerset—Crane Porcelain & Pottery Mfg. Co., Somerset, recently organized, care of Murray Rice, 516 West Laurel Street, San Antonio, Tex., architect, plans installation of electric power equipment in proposed new pottery at Somerset, where site has been acquired. Cost over $60,000, including machinery.

W. Va., Wheeling—Triangle Conduit & Cable Co., Dry Harbor Road, Brooklyn, N. Y., plans installation of electric power equipment in proposed new addition to wire and cable works at Glen Dale, Wheeling. Entire project will cost close to $100,000.

Wis., Tomahawk—Wisconsin Public Service Corporation, Bellin Building, Green Bay, Wis., has preliminary plans under way for new hydroelectric generating plant at Grandfather Falls, in vicinity of Tomahawk, to include transmission line for connection with present system, power substations and switching stations and other structures. Cost estimated close to $1,500,000. A. G. Carson is chief engineer.